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NEW METHODS FOR TESTING WORKABILITY AND COHESION OF COLD PATCHING MATERIAL

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by

Kai K. Tam

and

D.F. Lynch

Ontario Ministry of Transportation
Engineering Materials Office
Bituminous Section

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ABSTRACT

Two new test methods - Blade Resistance and Rolling-Sieve - have been developed for evaluation of the workability and cohesion properties of cold patching materials (CPM). The development of the two methods was based on simulation of field operation conditions and on using simple equipment normally available in an typical asphalt laboratory.

Studies were conducted to verify the applicability of the two methods for evaluation of CPM. Forty samples were obtained from all five regions in the province, covering a wide geographic area and providing a good representation of the CPM used. It was found that the new methods can quantitatively evaluate CPM. They have eliminated the problem of subjectiveness as existed in current methods. It is recommended that the two new methods be used as standard methods of testing. The requirements derived from this study for the two new methods (i.e. maximum 2000 N on blade resistance and minimum 60 % retained on the rolling-sieve) can be used as interim specification and should help in future designs of CPM. However, further verification of the requirements by field monitoring should be carried out before such standards are adopted as formal specification.

Test results from the forty samples sent in also show that, for good performance, the CPM should not be kept in storage for longer than ten months and the gradation requirement as outlined in the existing ministry specification should be followed.

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1. INTRODUCTION

Cold mix patching of potholes and minor surface defects is an accepted routine pavement maintainance process. The material cost alone is about $10 million a year in the province of Ontario. The amount of money involved is small relative to the value of hot mix placed annually. However, compared to the much longer service life experienced with hot mix, cold patching is costly. This is especially true when the patching is not performing as intended due to the use of poorly designed mixture and/or construction practices.

On reviewing the Ministry "Material Specification for Emulsified Asphalt Patching Materials", it was found that the test methods for workability and cohesion were highly subjective in nature. Other available literature showed similar lack of precision control test methods to evaluate the physical properties of cold patching material (CPM) and expressed the need for research in this area. In view of this, a project was therefore initiated to develop improved test methods for CPM.

2. CURRENT SPECIFICATION AND TEST METHODS

Three test requirements are specified in the current Ministry specification for the emulsified asphalt paching material only and none for the cutback (SC- 800) mixes. The tests are for stripping resistance, workability, and cohesion properties (App.1). The following is a brief discussion of the tests:

2.1 STRIPPING RESISTANCE

The test involves boiling 50 g of cold mix in distilled water for 3 minutes. Retained coating of less than 75 percent constitutes failure.

This is a simple and effective test to determine the stripping potential of cold mixes in general, despite the fact that boiling a mix in water is considered a severe treatment and does not simulate field conditions. However, it is an accelerated test and, with little backup data available to disprove such practice, the test is therefore recommended to be retained in its existing form and no further work is to be done on it in this study.

2.2 WORKABILITY

The workability of a CPM determines how easily an operator can handle (i.e. shovelling, raking and shaping) a mixture in the stockpile and how well it can be placed and compacted in deteriorated areas in cold weather conditions.

This property is deteriorating as materials are stockpiled for longer periods of time due to the aging of binders.

The present test calls for placing the materials in a cold room at -10°C for 24 hours. Evaluation is made as to the effort required to penetrate and rework the mix. If a mix allows the scoop to enter with reasonable ease, the mixture is considered workable. This technique lends itself to the subjective judgement of operators as well as to variations in the physical strength of the person carrying out the test. Therefore, this test requirement is not considered desirable due to lack of quantitative criteria.

2.3 COHESION

Failure in the form of ravelling is one of the most common occurrences in cold mix patching. It is often due to the poor cohesion existing either between the patched material and the wall of the potholes or within the mixture itself. This type of failure is also aggravated by poor lay down practices. Often, water or snow in the potholes are not removed and mixtures are placed with little or no compaction. Therefore, improvement in mix cohesion will almost certainly to reduce ravelling failure. Hence there is a need for a quantitative method for testing the cohesion property of CPM.

Although the current specification calls for a cohesion test, the test itself is merely an observation of how well a lump of material is held together by itself after being squeezed by hand at -10°C. Again, this is highly subjective and sensitive to the strength and judgement of the operator. This is another case where there is a need for a quantifying test.

3. OBJECTIVE OF STUDY

In view of the limitations of the existing methods, this study sets out to develop appropriate test methods which will quantify the workability and cohesion properties of CPM. The approach involves first developing suitable test methods and then verifying them through field observations and sampling from different geographic locations in the Province. The input data such as the field ratings on material workability and cohesion by operators from the regions are correlated with laboratory results.

4. DEVELOPMENT OF TEST METHODS

Different ideas were explored at the initial stage of the study for testing the workability and cohesion properties. For example, an inverted cone test

similar to the concrete slump test was tried to measure the cohesion of CPM. The test was simple but results were not reproducable, even with modifications such as including surcharge weight and changing of compaction procedures. For workability, Marshall testing with reduced compactive effort in cold temperature (-10°C) was tried. Again the results were not conclusive. However, these trials did give some insights as to what really is required for testing of cold patching material.

However, on reviewing the experience gained from these trials, the following factors were identified as the basis for developing the methods for these two properties in the next stage of the development:

a) simulation of the field handling characteristics,
b) simplicity for use under field operation conditions, and
c) utilization of available equipment, with minimal modifications or purchase of new parts.

With these in mind, the methods described below were developed:

(i) Workability of Cold Patching Bituminous Mixtures by Blade Resistance Test, and
(ii) Cohesion of Cold Patching Bituminous Mixtures by Rolling-sieve Test

4.1 BLADE RESISTANCE TEST FOR WORKABILITY

The method is described in detail in Appendix 2. The test involves measuring the resistance in Newton (N) of a compacted sample, at -10°C to the penetration of a blade after 30 seconds of load application at 50 mm/min using the Marshall testing apparatus. The higher the resistance, the poorer is the workability.

A modified adaptor to the bottom of the proving ring attachment of the Marshall testing apparatus was made. The adaptor consists of a metal blade measuring 130 mm wide, 50 mm high and 3 mm thick.

Duplicate samples are prepared in two wooden boxes by compacting about 5 kg of CPM with a modified flat foot square hand held Marshall hammer at room temperature. The samples are then conditioned in a cold room or a freezer to -10°C for a minimum of 12 hours before testing begins. The compaction of materials at room temperature is to simulate the consolidation that has been taken place in a stockpile.

The idea is to simulate the penetrating action of a scoop or shovel into a mix in cold weather as in the case of the present test. The maximum effort

required to penetrate the mix is measured mechanically by the proving ring dial.

4.2 ROLLING-SIEVE TEST FOR COHESION

This test as described in Appendix 3 is a very simple test involving rolling a compacted briquette in a 19 mm square opening sieve of 305 mm in diameter. Except the freezer unit and/or a large metal tray all of the equipment involved is common items in an asphalt laboratory. The sample is prepared by using a Marshall hand-held hammer and mould and compacted at -10°C. The percentage of materials retained on the sieve after rolling is called the cohesion index. The higher the index, the better is the cohesion.

This test is developed with the idea that, when the compacted briquette is subjected to the disturbance and attrition of a rolling sieve, the material retained on the 19 mm sieve would give an indication as to the bonding or cohesion properties of the mixture. The attrition between the sieve and the surface of the briquette simulates to some extent the abrasion of traffic on a CPM.

4.3 PRELIMINARY EVALUATION

Before any major work was to be performed, a pilot study was set up to determine if the two methods were satisfactory. The preliminary evaluation (App. 4) of the two methods involved correlating the visual observation or ratings of CPM with the results obtained from the tests. At this stage, only six mixtures were tested, two from Thunder Bay District and four from Toronto area. These mixes covered a range of workability and cohesion as judged by past experience.

For the rolling-sieve test, different hammer blows from 3 to 10 were experimented. The low number of blows was to simulate the poor compaction normally experienced in the field. It was found that the 5-blow per side compaction appeared to provide a reasonable separation of the good from the poor mixes (as shown in Fig. 1 of Appendix 4).

For the blade resistance test, the results showed that a good trend existed between the blade resistance values and the visual ratings of the mix workability as assessed by the existing method.

In general, the tests developed seemed to be able to discriminate the poor from the good mixes. Therefore, a larger scale study involving different regions was initiated to confirm the reliability of these two test methods.

5. CORRELATION WITH FIELD EVALUATION

In conjunction with the Maintenance Branch, requests were made to the 16 districts in the five regions for the supply of 30 kg of CPM samples from the mixes in use in their areas at the time. The samples were sent to the Evaluation Laboratory at Downsview for testing. At the same time, they were asked to complete a questionnaire (App. 5) on information relating to observations on field handling and performance.

5.1 QUESTIONNAIRE

The questionnaire was divided into two parts. Part 1 was on the field data such as mix information, stockpile, mix handling rating on the workability and cohesion properties, and field application conditions (e.g. potholes, climate and compaction methods). The handling properties were rated on a scale of 1 to 10 for the poor to good mixtures. The application data included information on the weather conditions under which cold patching work was done. Part 2 was on the field performance of CPM. Observations on the resistance to rutting and ravelling were made after about two weeks of opening to traffic. An attempt was also made to obtain information on the summer performance of similar mixes that had been placed the previous winter. The field performance properties were also rated on a scale of 1 to 10 for light to severe rutting or ravelling.

5.2 RESULTS

Of the forty samples sent in from different patrols in the districts, twelve were mixes with cutback binder and twenty seven were emulsified asphalt mixes (with one unknown).

The samples received from the field were tested for:

a) Mix composition

- residual A.C. content
- maximum aggregate size
- % retained on 4.75 mm sieve
- gradation

b) Mix properties

- Blade resistance workability test in the laboratory
- Rolling-sieve cohesion test in the laboratory
- Workability rating by existing method

- Cohesion rating by existing method
- BRD compacted at -10°C and 5 blows per side by Marshall hammer
- BRD compacted at 25°C and 60 blows per side by Marshall hammer

There was a large amount of data from the response of the questionnaire (Table 1) as well as results from the laboratory tests (Table 2). These are analyzed and discussed in four main areas:

- Workability
- Cohesion
- Mix Composition
- Mix Performance

5.2.1 Workability

The workability property of the CPM was evaluated at the stockpile and the site. The same mixtures were rated and tested in the laboratory using the newly developed blade resistance method. Also, the effect of storage time on the workability of CPM was evaluated. The comparison of different rating results and their relationships are discussed as follows:

i) *Field and Laboratory Workability*

The frequency of occurrence of different ratings for the population of 40 samples is plotted in Fig. 1. It shows that relatively better correlation was obtained between stockpile and site ratings than with the laboratory ratings. Correlation coefficients (r) of 0.57 and 0.39 were obtained respectively (Fig. 2). More than 80% of the mixes rated as good in the field were under the poor category when they were rated in the laboratory. These discrepancies were due to the higher rating temperatures at which the field ratings were carried out. Also, some mixes had been stored in heated storage (e.g. patrol yard garages) prior to their use. While the laboratory rating temperature was kept at -10^{o}C, the field rating of the mixes was performed under a large variation of application temperatures, ranging from +12 to -6°C (Table 1). However, since CPM is expected to be used in colder temperatures i.e. at or below -10^{o}C, the laboratory evaluation temperature of -10^{o}C is therefore considered realistic and representative of the critical temperature experienced. It is expected that, if a mix is workable at -10^{o}C, it would be satisfactory at higher temperatures.

ii) *Field Workability and Blade Resistance*

Based on the discussion above, the relationship between the site or

stockpile workability rating and the blade resistance is expectedly poor (Figs. 3a and 3b). A (r) value of 0.38 was obtained.

iii) *Laboratory Workability Rating and Blade Resistance*

This is one of the most important relationships to look for as far as ensuring if the new test method is at all appropriate for use in evaluating the workability property of CPM. However, because of the subjectiveness of the existing rating methods as mentioned, good correlation is not expected for this relationship, despite the fact that the laboratory rating was performed under controlled conditions.

The reason for this correlation is to determine if results from the new test method do follow a trend similar to that obtained by using the existing method. Fig. 3c confirms the trend, established during the initial or pilot study, that as the workability is reduced, the resistance of the cold mixes to the penetration of the blade is increased. A correlation coefficient of (r) = 0.44 was obtained. Results from both the initial and present studies showed that the mixes which were considered not workable had blade resistance values of exceeding 2000N.

The fact that slightly better correlation is obtained between the laboratory rating and blade resistance (r = 0.44, Fig. 3c) than laboratory rating and site rating (r = 0.39, Fig. 2c) or with stockpile (r=0.08, Fig. 2b) shows that the new method is an improvement over the existing one.

iv) *Effect of Compaction on Blade Resistance*

An alternative way of evaluating the ability of the blade resistance method to determine the workability of CPM is by looking at the relationship between the relative compaction of the mixtures at -10°C and 23°C (room temperature) and at 5 blows and 60 blows of Marshall hammer compaction respectively.

As expected, the more compactable mixes showed less blade resistance (Fig. 4). The correlation was not good with a (r) value of 0.55, because the relative compaction is a measure of the compactability of a mix and it is only indirectly related to the mix workability property. The trend, however, shows that the use of blade resistance test to evaluate workability is a viable method.

v) *Field Workability and Storage Time*

When a CPM is stockpiled in the open for an extended period of time,

it becomes harder to handle because of the aging of the binder and consolidation of materials. Figs. 5a and b show that, the workability rating droped very rapidly within the first ten months of storage and, when the mixes were stockpiled for more than twelve months, they became very unworkable. The same trend was also detected by the blade resistance test (Fig. 5c).

5.2.2 Cohesion

The evaluation approach to the cohesion property was similar to that used for the workability. The relationships are examined below:

i) *Field and Laboratory Cohesion*

Similar to the workability, the cohesion ratings of most of the 40 samples were better in the field (i.e. the stockpile and site) than in the laboratory (Fig. 6). This again is due to the different raters and various temperature conditions at which the mixes were rated. However, the rating between the stockpile and the site appeared more consistent with a (r) value of 0.71 (Fig. 7). It is noted that the ratings for both stockpile and the site were done at very similar temperatures, hence the better correlation. The laboratory to stockpile or laboratory to site relationships were insignificant.

ii) *Field Cohesion and Percent Retained Rolling-Sieve*

A slightly better correlation is obtained between the percent retained on the rolling-sieve test and field ratings than with the laboratory rating (Fig. 8). A (r) value of 0.61 and 0.60 were obtained for the stockpile and site respectively versus a (r) = 0.40 for the laboratory with retained rolling-sieve (Fig. 8c). This is encouraging in that the new method can better simulate the field assessments than those for the laboratory.

However, correlation between the laboratory rating and the rolling-sieve test ($r = 0.40$) is better than the correlation between the laboratory and the field ratings ($r = 0.17$ and $r = 0.26$ for stockpile and site respectively, Fig. 7). Therefore, the new test method is an improvement over the existing method.

The curves in Fig. 8 suggest that mixtures which have over 60% retained on the rolling-sieve are considered to have sufficient cohesion (at a rating of about 4).

iii) *Effect of Compaction on the Percent Retained on Rolling-sieve*

One of the concerns when developing the rolling-sieve test was the degree of laboratory compaction of CPM that could be used in the test to differentiate the good from the poor mixtures. The degree of compaction should also be realistic and simulate the type of compaction experienced in the field.

The achievable field compaction of CPM in potholes was estimated by placing some loose mixes at -10^{o}C in an 100 mm (4in) diameter mould to a thickness of about 60 mm (2.5in). The density was measured after the mix was compacted by tamping with a foot until it looked reasonably dense as in the field. The compaction was about 65 to 75% of the density obtained by compacting the same mixture at 60 blows with a Marshall hammer at 25°C. The density at 60 blows represents the best possible or full compaction. By trial and error, 5 blows of Marshall hammer were found to give the estimated field compaction (Table 2). This level of compaction also gave a reasonable separation of the good from the poor mixes in the test.

Fig. 9 shows that there was a tendency for the more compactable mixes to achieve the 60% minimum retained on the rolling-sieve test.

(iv) *Effect of Storage Time on the Cohesion of Mixes*

Similar to the workability property, the cohesion of CPM is reduced with prolonged storage due to hardening of the binder. The curves in Figs.10a and 10b confirmed the findings stated for workability that sharp drop in cobesion was observed within the first ten months of storage and that the cohesion of the mixes was considered poor after more than twelve to fifteen months of stockpiling.

With the suggested standard of minimum 60% retained on rolling-sieve the trend in Fig.10c confirms the field observations that the cohesion became unsatisfactory after about ten months of storage.

5.2.3. Gradation and Mix Properties

(i) *Gradations*

The gradations of all 40 mixes were compared with the specification as per Form 1153 Table 1 (Fig. 11) Only seven out of the 40 were outside the specification limits and they were open graded mixes. Most of these off-specification mixes were high stone content cutback CPM .

(ii) *Binder types*

There were twelve mixes using cutback as a binder and the rest were emulsion mixes. Figs.1 and 6 show that more good mixes were obtained by using the emulsion than the cutback. However, this could be because most of the cutback mixes had been in storage longer than the emulsion mixes i.e. more aging of the binder.

(iii) *Gradation and Workability*

Four different sizes of the gradation (e.g. maximum size, pass 4.75 mm, pass 300μm and pass 75 μm) were examined in respect to the workability ratings from the stockpile and site as well as to the blade resistance values. The purpose is to determine if the percentage of each of the sizes affects the rating and blade resistance. The graphs (Figs. 12 to 14) showed poor correlation existed between the four gradation sizes and the ratings at the stockpile, site and laboratory. However, some trends appear to exist. The following describes the interpretation of the curves which showed some kind of trend (Table 4):

- Maximum size: the relationship of maximum size and the blade resistance showed that the mixes with an aggregate maximum size of 12 mm were more likely to produce blade resistance values of less than 2000 N (Fig. 14). The maximum size did not show any trend with the stockpile or site ratings at all. As the maximum aggregate size is increased, the chance of the blade or shovel hitting the stone fraction is increased thus producing a poor rating for the mix.

- % passing 4.75 mm: The relationship with both the blade resistance and site rating showed that mixes with between 64% to 68% of passing 4.75 mm materials would more likely to produce an acceptable workability. There was no trend observable from the graph for the stockpile rating.

- % passing 300 mm: The relationships with the stockpile and site ratings showed that mixes with a minimum 15% passing 300 μm sieve would more likely to produce ratings of medium to good workability (Figs. 12 and 13).

- % passing 75 μm: The stockpile and site ratings and the blade resistance test results showed that a minimun of 3% passing 75μm would generally produce satisfactory workability.

(iv) *Gradation and Cohesion*

A similar evaluation was made to examine the effects of mix gradation on the cohesion property of CPM (Figs. 15 to 17). The evaluation shows that the:

- aggregate maximum size should be smaller than 15 mm (based on a minimum of 60% retained on the rolling-sieve, Fig.17a).

- % passing 4.75 mm should be about 60% (based on the relationship with stockpile ratings at 4 and above).

- % passing 300 μm should be around 15% (based on stockpile and site ratings as well as the rolling-sieve test).

- % passing 75 μm should be around 3.2% (again based on the stockpile and site ratings and the rolling-sieve results).

(v) *Existing Gradation Requirement*

The above findings were used to determine the optimum composition and to compare it with the existing gradation envelope as per Form 1153, Table 1. The percentage of the four gradation sizes were calculated by averaging the values obtained from the three test conditions (i.e. laboratory, stockpile and site) for the workability and cohesion properties (Table 3). They were found to be exactly in the middle of the range given in the grading envelope. This shows that the existing specification is in good order.

5.2.4 Mix Performance

The field evaluation was performed about a week or two after the placement of the CPM. The results (Table 1 and Fig. I8) show that most of the mixtures performed well in so far as rutting and ravelling were concerned.

5.2.5 Validity of New Test Methods

Based on the above analysis and discussion on the various relationships and trends of results obtained from the field and the two new methods, it appears that the two methods are viable tests for the workability and cohesion properties of CPM.

6.0 DESIGN REQUIREMENTS

Based on the evaluations in the field and in the laboratory, the gradation, workability and cohesion requirements can be summarized as follows:

(a) Existing gradation requirements as per Form 1153 should be followed.

(b) Workability requirement using the newly developed "Blade Resistance" test should be below 2000 N.

(c) Cohesion requirement using the newly developed "Rolling-Sieve" test should be more than 60% retained.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Two new methods - Blade Resistance and Rolling-Sieve - have been developed. The applicability of the methods for testing the workability and cohesion properties of CPM have been evaluated. It can be concluded that the two test methods can provide for a more quantitative and non-subjective evaluation of CPM and could be used as standard methods of testing. The requirements derived from these two new methods are (a) maximum 2000N on the blade resistance and (b) minimum 60% retained on the rolling-sieve. These criteria should be observed for the design of CPM.

Test results from the forty samples obtained from a wide geographic area provided a good coverage of CPM used in the province. The results showed that, for good performance, the CPM should not be kept in storage for longer than ten months and, the gradation requirement as outlined in the existing specification should be followed.

It is recommended, however, that further verification of requirements by field monitoring should be carried out before such standards are adopted as formal specification.

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Table 1: Results of Response from the Districts on the Questionnaire

Sample No.	District / Patrol	Binder Type	Age of Stockpile (mos.)	Heated Storage (Y/N) (C)	Air temper. (C)	Rating Number								Pothole Description		
						Workability		Cohesion		Rutting		Ravelling				
						Stockp.	Site	Stockp.	Site	Winter	Summer	Winter	Summer	Size (mm)	Depth (mm)	Condition
1	1/9	E	1	No	4	8	4	4	4	3	NA	4	NA	300	100	Dry
2	1/12	E	0	No	8	8	8	6	6	3	NA	4	NA	300	50	Dry
3	1/14	E	1	No	4	5	6	4	8	8	NA	6	NA	130	40	Dry
4	2/7	C	5	Yes	0	7	6	9	9	2	NA	2	NA	180	60	Dry
5	2/17	C	.25	Yes	3	9	7	8	8	3	NA	2	NA	380	100	Dry
6	3/13	E	2	No	6	9	7	8	6	2	NA	1	NA	300	70	Wet
7	4/4	E	.25	Yes	3	7	6	6	5	6	6	NA	NA	230	70	Dry
8	4/12	C	.25	Yes	3	4	8	7	7	2	NA	2	NA	600	40	Dry
9	4/17	E	1	No	23	9	9	5	6	3	NA	4	NA	380	80	Wet
10	5/8	E	6	Yes	5	7	8	8	8	1	3	1	1	230	100	Wet
11	5/13	E	5	Yes	3	8	7	8	6	3	NA	3	NA	300	50	Dry
12	5/18	E	5	Yes	5	9	9	6	6	2	6	1	1	250	120	Dry
13	7/1	E	4	No	0	6	8	7	7	3	NA	7	NA	230	70	Dry
14	7/7	E	4	Yes	7	2	2	9	8	3	NA	5	NA	250	100	Dry
15	7/13	E	4	No	4	6	6	6	7	8	6	5	6	250	70	Dry
16	9/1	E	6	Y(+4C)	4	9	8	8	8	5	8	4	2	610	76	Wet
17	9/8	E	6	No	3	8	7	8	7	3	6	4	4	610	102	Dry
18	9/23	E	6	No	-6	5	8	9	9	3	9	3	7	200	102	Wet
19	10/1	E	5	No	-4	8	8	8	8	1	2	1	2	610	38	Dry
20	10/5	E	6	No	5	8	8	7	6	2	3	2	2	280	89	Wet
21	10/7	E	6	No	10	4	7	7	7	2	1	2	1	230	102	Wet
22	11/2	C	7	Y(+13C)	2	1	7	8	4	3	8	2	6	760	76	Dry
23	11/8	E	7	No	4	7	8	7	8	3	3	2	3	200	76	Dry
24	11/14	C	7	Y(+10C)	5	1	2	2	2	2	3	2	3	300	76	Dry
25	13/4	E	7	No	4	8	8	7	7	1	NA	1	NA	100	100	Dry
26	13/6	E	6	No	0	8	9	7	7	2	1	2	1	180	51	Dry
27	13/7	E	7	Y(+18C)	6	4	8	5	6	NA	NA	2	2	300	51	Dry
28	14/5	C	33	Yes	2	2	1	7	7	2	8	1	4	300	50	Dry
29	14/9	C	8	Y(-6C)	-6	2	2	1	2	1	6	3	2	300	60	Snow
30	14/14	C	9	No	4	6	9	9	8	2	2	1	2	370	38	Dry
31	16/1	C	19	No	10	3	7	3	3	1	1	7	1	280	38	Dry
32	16/3	C	30	Y(+15C)	4	3	4	4	4	1	3	1	4	410	76	Dry
33	16/6	C	18	No	25	1	1	1	1	NA	NA	NA	10	310	89	Dry
34	17/4	E	7	No	7	6	6	7	7	2	3	1	3	250	51	Wet
35	17/5	E	6	No	12	3	3	5	5	2	NA	3	NA	180	51	Dry
36	17/16	E	7	No	-2	8	8	8	8	3	6	3	7	170	51	Dry
37	18/1	C	8	No	2	2	4	7	7	2	3	3	2	330	64	Dry
38	19/7	NA	12	No	11	8	8	8	8	1	NA	3	NA	310	64	Dry
39	20/1	E	6	Yes	4	8	9	7	7	2	NA	3	NA	450	64	Dry
40	20/3	E	9	No	8	8	9	8	7	1	NA	3	NA	250	114	Dry

E = Emulsified Asphalt Mix
C = Cutback Mix
NA = Data Not Available

Table 2: Laboratory Test Results

Sample No.	Resid. A.C. (%)	Gradation (% Retained on Sieve, mm)										Max. Aggr. Size (mm)	Bulk Rel. Dens.		Relat. Compaction (%)	Blade Resistance (N)	Retain on Rol Sieve (%)	Lab.Rating No.	
		13.2	9.5	6.7	4.75	2.36	1.18	.600	.300	.150	.075		at -10C 5 blows	at 25 C 60blows				Workability	Cohesion
1	3.85	0	7	33	46.4	56	64	71	83	94	96	13.2	1.699	2.421	70.2	1779	93.6	2	1
2	3.63	0	11	40	50.8	61	68	75	86	95	98.3	13.2	1.679	2.353	71.4	2313	98.7	2	2
3	3.73	0	11	39	51.1	60	67	74	85	94	98.2	13.2	1.541	2.387	64.6	1868	91.7	1	1
4	3.83	0	0	20	66	91	94	96	97	97	97.5	9.5	1.428	2.055	69.5	2402	99.2	1	1
5	3.98	0	0	22	69.6	92	96	97	97	97	97.1	9.5	1.432	2.118	67.6	2713	98.6	1	1
6	3.75	0	0	8	38	63	72	81	89	94	95.5	9.5	1.701	2.401	70.8	1423	99.5	4	2
7	4.39	0	0	2	18.6	43	56	70	81	87	92.3	6.7	1.555	2.439	63.8	1245	98.7	6	2
8	5.64	0	0	1	14.5	82	92	95	96	96	96.7	6.7	1.426	2.262	63.0	1957	100.0	2	9
9	3.98	0	0	12	47.1	87	94	96	97	97	97.7	9.5	1.483	2.188	67.8	801	100.0	1	2
10	5.13	0	0	2	24.8	48	59	73	88	94	94.6	6.7	1.812	2.379	76.2	890	100.0	6	5
11	4.77	0	8	19	29.6	43	55	69	86	94	96.6	13.2	1.769	2.400	73.7	3603	100.0	2	5
12	5.31	0	11	25	35.5	49	60	74	88	95	96.7	13.2	1.613	2.401	67.2	2936	99.8	1	5
13	4.05	1	13	31	44.5	54	62	72	85	94	95.5	13.2	1.511	2.432	62.1	3380	99.1	2	5
14	5.15	0	0	4	37.8	84	93	95	96	97	97.5	6.7	1.420	2.165	65.6	2669	97.0	1	2
15	3.76	1	12	27	36.4	44	51	61	78	91	96.5	13.2	1.587	2.394	66.3	2491	98.6	4	2
16	4.04	0	13	32	45.4	52	57	65	78	91	92.5	13.2	1.580	2.471	63.9	4270	99.1	3	2
17	3.49	0	15	37	48.7	55	60	67	79	90	95.4	13.2	1.617	2.462	65.7	2446	94.7	2	3
18	3.28	0	14	38	49.5	55	59	66	76	90	95.8	13.2	1.596	2.453	65.1	2446	96.6	2	1
19	3.68	0	3	19	31.9	47	59	69	80	90	95.5	9.5	1.623	2.370	68.5	1290	98.9	6	5
20	3.74	0	4	19	31.5	46	58	69	80	90	95.8	9.5	1.665	2.343	71.1	1423	95.5	4	4
21	4.25	0	2	16	27.3	41	55	67	79	89	92.9	9.5	1.649	2.386	69.1	1423	91.2	4	4
22	4.03	0	7	21	29.4	39	51	65	84	95	98.4	13.2	1.537	2.180	70.5	1957	69.3	5	1
23	3.51	0	17	28	32.9	46	59	76	91	97	98.7	13.2	1.536	2.245	68.4	1112	97.4	4	4
24	4.05	0	14	26	31.9	46	58	76	91	97	98.5	13.2	1.563	2.122	73.7	2135	6.7	4	1
25	3.41	1	10	16	21.8	34	49	65	80	90	95	13.2	1.548	2.283	67.8	2669	96.3	7	7
26	3.42	1	9	15	20.2	32	44	60	76	88	94.1	13.2	1.547	2.312	66.9	1601	98.6	7	8
27	4.02	0	7	15	21	33	47	62	78	89	94.3	13.2	1.484	2.337	63.5	2135	75.0	7	5
28	4.19	2	16	26	35.4	48	61	78	91	95	96.9	13.2	1.446	2.250	64.3	4746	72.4	1	1
29	4.5	3	16	26	34.6	50	64	80	90	94	96	13.2	1.410	2.293	61.5	2491	97.6	1	1
30	4.35	4	19	28	36.7	52	66	81	90	94	96	13.2	1.426	2.203	64.7	4270	84.9	3	1
31	5.18	2	11	16	24.2	39	54	70	84	92	95.4	13.2	1.370	2.135	64.2	1824	53.8	2	1
32	4.97	4	19	30	38	50	63	76	87	93	96.3	13.2	1.489	2.280	65.3	6601	24.4	1	1
33	4.1	13	27	39	49.9	67	81	86	90	93	94.4	19.0	NA	NA	NA	2224	0	0	1
34	3.8	3	13	28	38.9	50	61	75	90	95	96.8	13.2	1.466	2.307	63.5	2224	85.6	3	5
35	3.76	1	11	22	33.3	48	61	73	86	94	96.6	13.2	1.394	2.361	59.0	5782	61.0	1	1
36	3.67	1	9	19	29.4	46	59	72	85	93	96.4	13.2	1.483	2.357	62.9	1868	92.8	2	4
37	5.04	9	25	40	49.5	57	64	72	85	94	97.3	16.0	1.291	2.339	55.2	5115	65.6	1	1
38	4.28	0	1	11	31.9	51	60	66	78	91	95.4	9.5	1.488	2.257	65.9	2936	96.9	8	5
39	4.37	0	2	6	11.9	30	46	63	82	91	95.6	9.5	1.674	2.243	74.6	1023	99.5	7	8
40	4.45	0	0	9	29.5	50	59	65	75	91	95.2	9.5	1.459	2.379	61.3	4181	79.6	1	1

NA - Data Not Available

Table 3: Gradation Profiles for Good Cold Patching Material and Comparison with Existing Specification

Parameter	Workability			Cohesion			Avg.	Form 1153
	Bl. Res. (@ 2000 N)	Stock	Site	R. Sieve (60% ret.)	Stock	Site		
Max. Size (mm)	12	x	x	15	x	x	14	14
% passing 4.75mm	68	x	64	x	60	x	64	50-85
% passing 300 um	x	15	15	16	15	14	15	7-25
% passing 75 um	4.0	4.4	3.8	3.7	3.0	2.9	3.6	0-7

x = not available

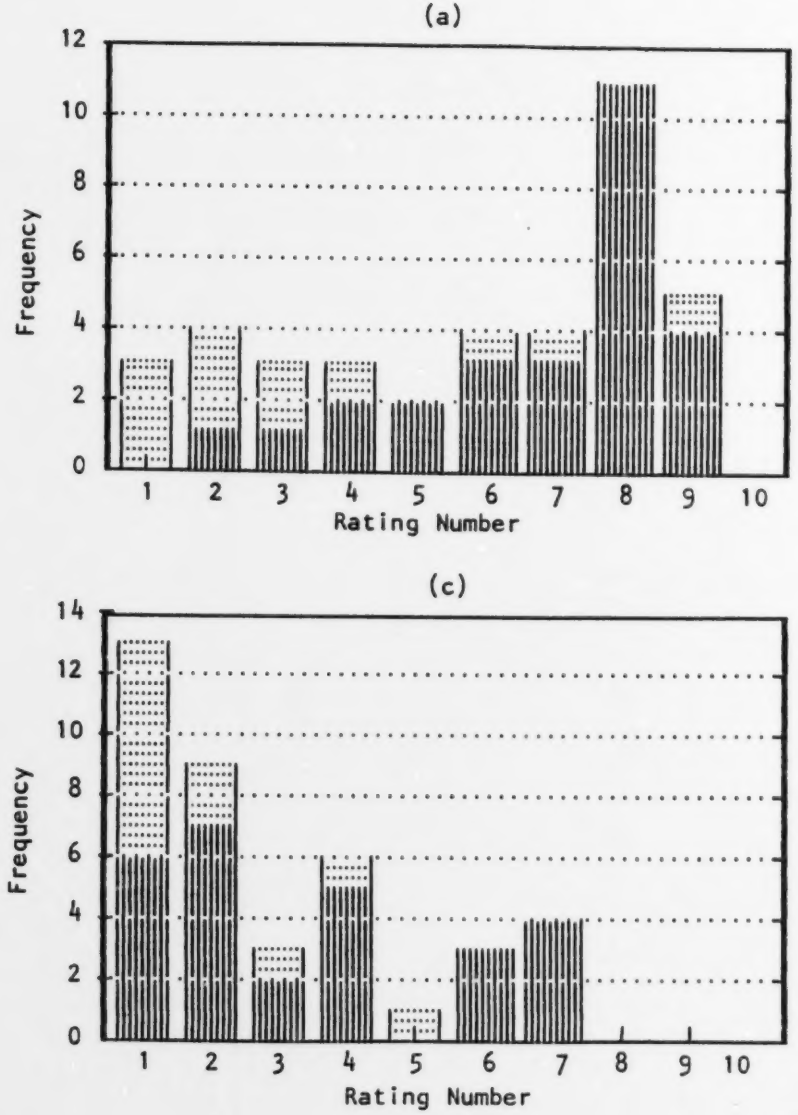
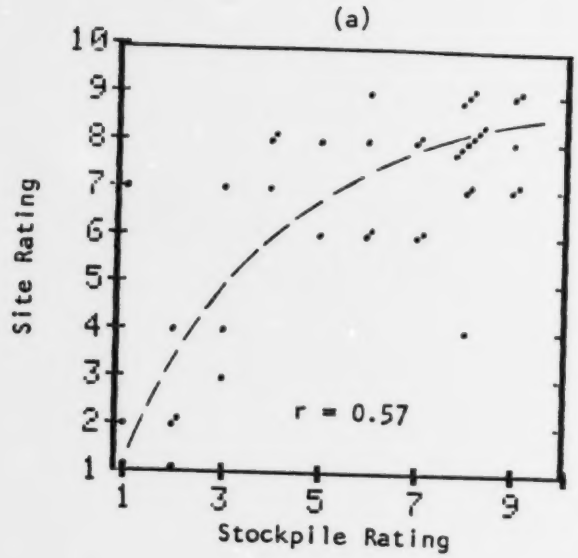
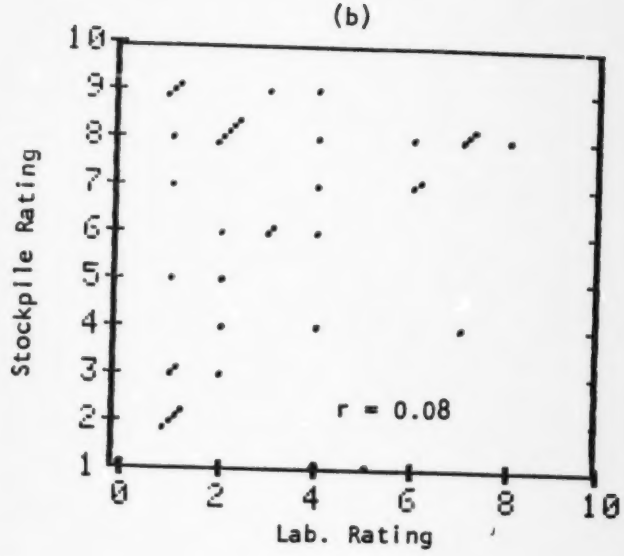


Fig. 1: Histogram of Workability Rating for (a) Stockpile, (b) Site, (c) Laboratory

Note: = Emulsion Mixes
= Cutback "

Rating Scale : 1 - 3 Poor
4 - 7 Medium
8 - 10 Good





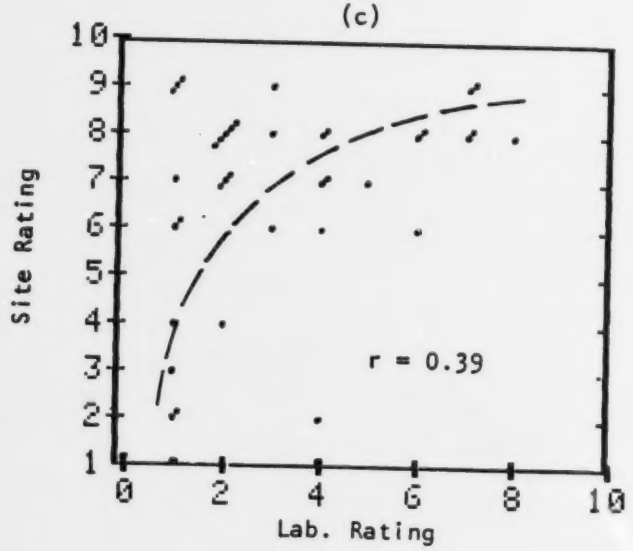
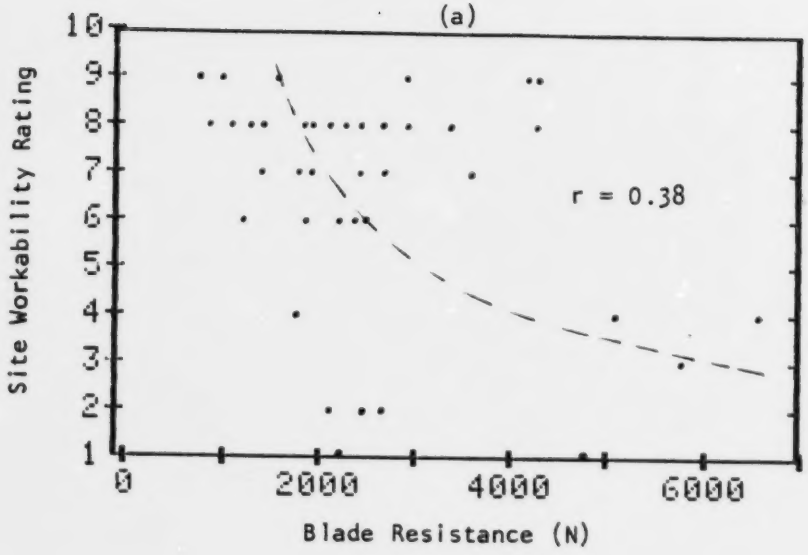
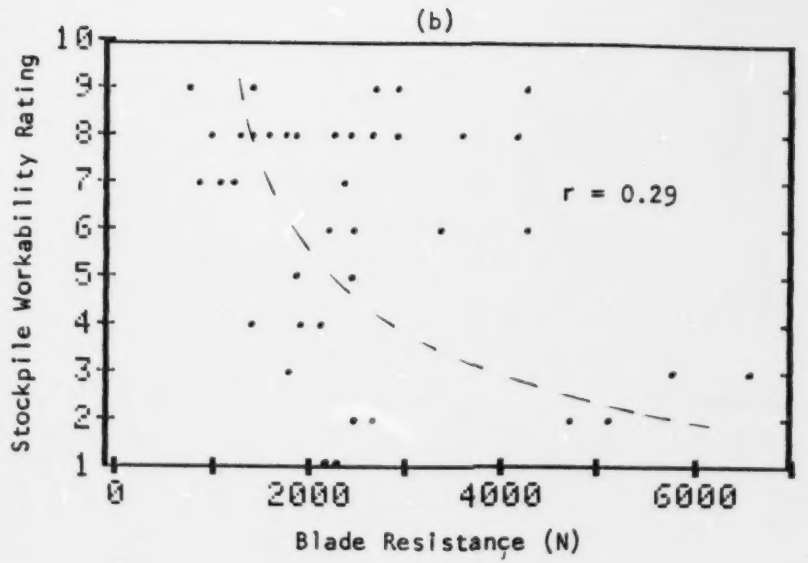


Fig. 2: Relationship of Workability Rating Between:

a) Stockpile vs. Site
b) Lab. vs. Stockpile
c) Lab. vs. Site

Note: Rating Scale: 1 - 3 poor
4 - 7 medium
8 - 10 good





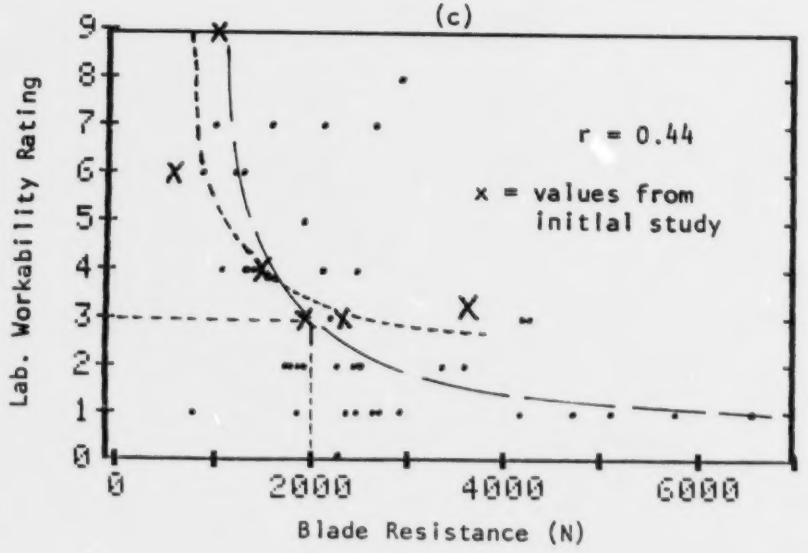


Fig. 3: Relationship of Blade Resistance and Workability Rating for:

(a) Site, (b) Stockpile, (c) Laboratory

Note: Rating Scale: 1 - 3 Poor
4 - 7 Medium
8 - 10 Good

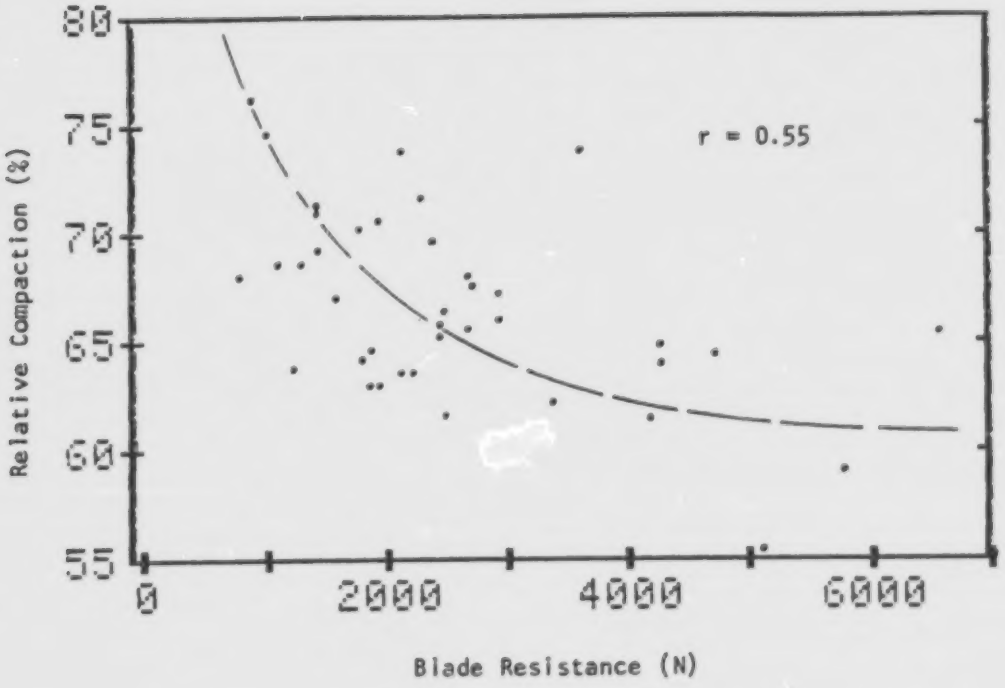
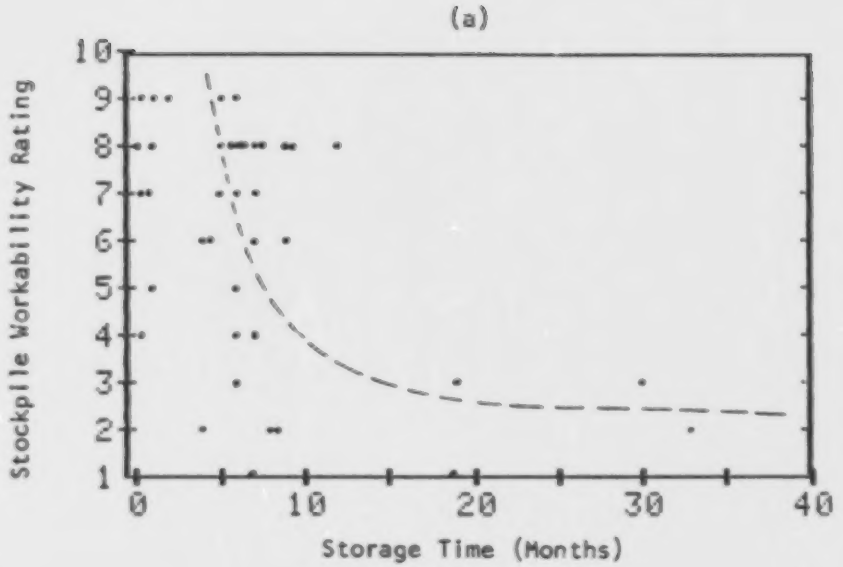
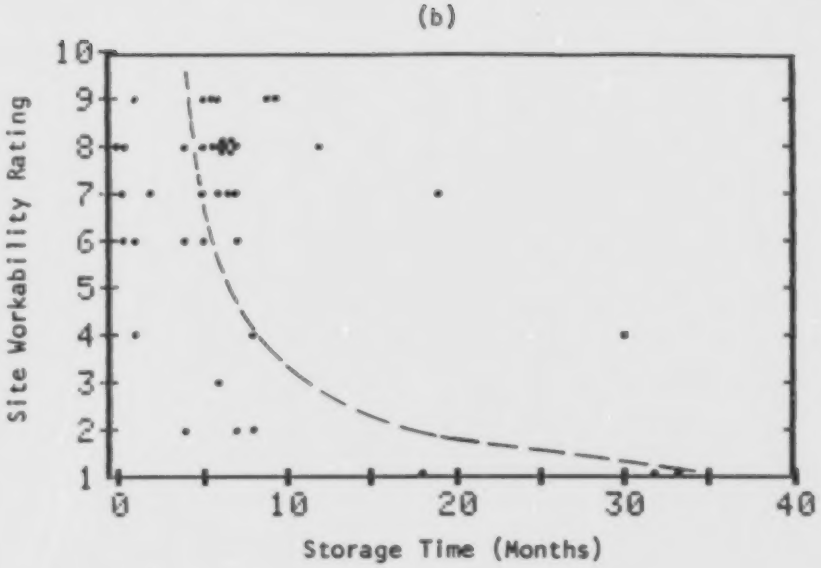


Fig. 4: Relationship of Compactability (Relative Compaction, %) and Blade Resistance (N)





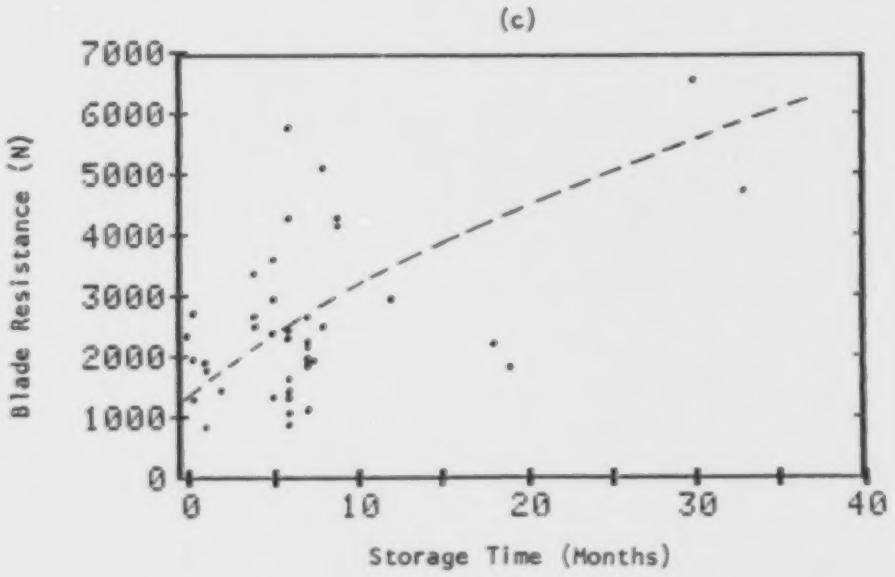


Fig. 5: Effect of Storage Time on Workability of Mixes:

a) Stockpile Rating
b) Site Rating
c) Blade Resistance Test Results

Note: Rating Scale: 1 - 3 Poor
4 - 7 Medium
8 - 10 Good

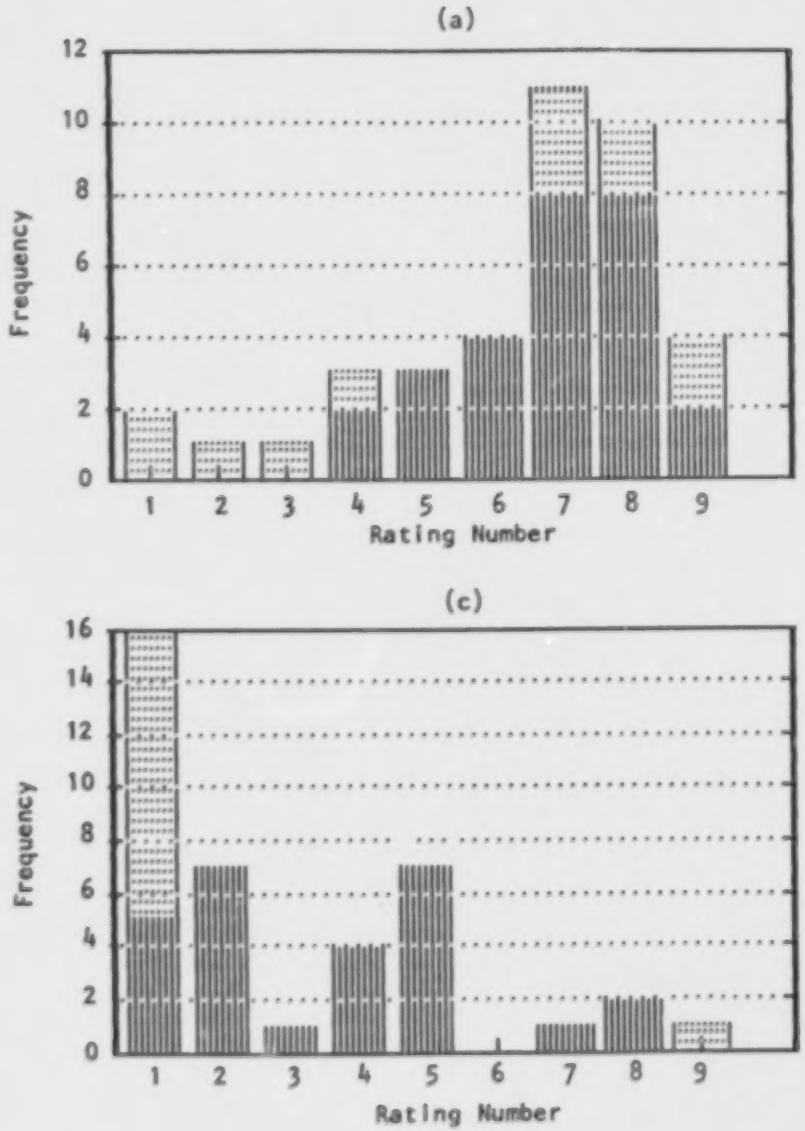
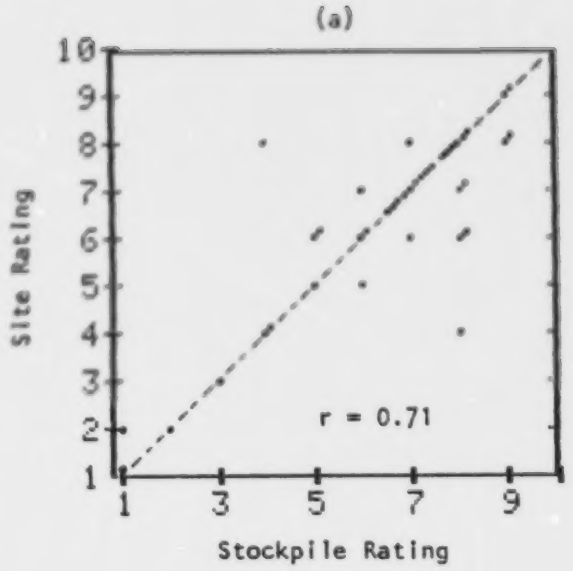


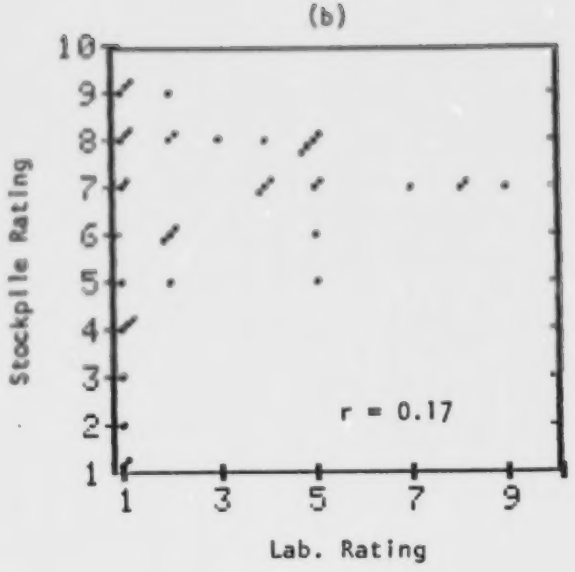
Fig. 6: Histogram of Cohesion Rating for:

(a) Stockpile, (b) Site, (c) Laboratory

Note: = Emulsion Mixes
= Cutback Mixes

Rating Scale: 1 - 3 Poor
4 - 7 Medium
8 - 10 Good





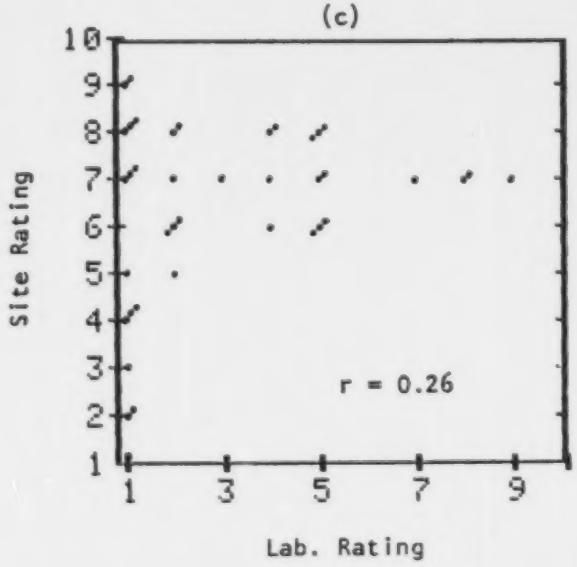
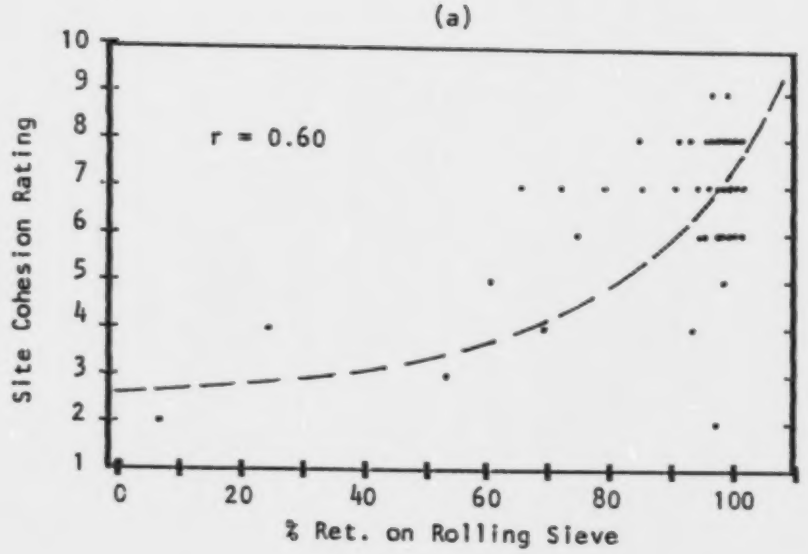
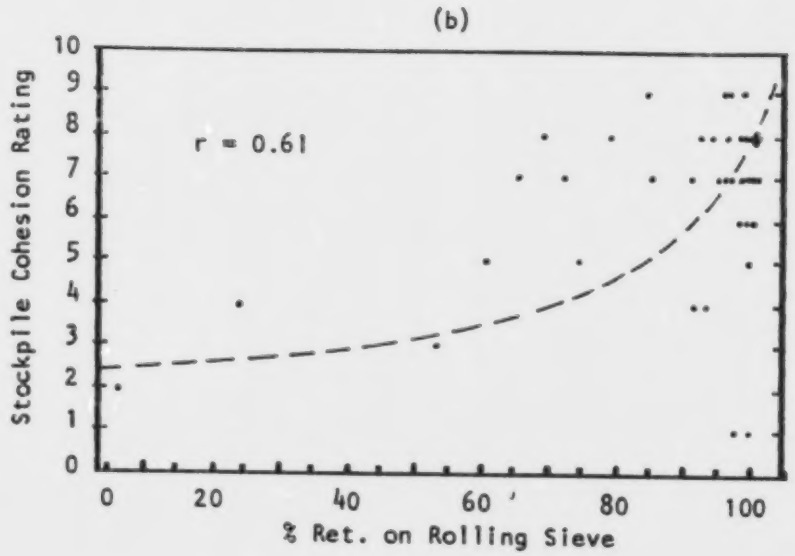


Fig. 7: Relationship of Mix Cohesion Rating Between:

a) Stockpile vs. Site
b) Lab. vs. Stockpile
c) Lab. vs. Site

Note: Rating Scale: 1 - 3 Poor
4 - 7 Medium
8 - 10 Good





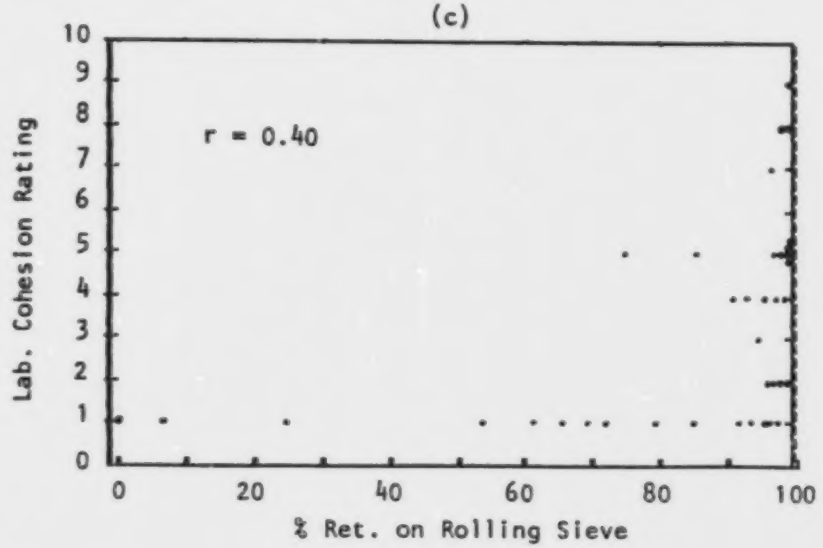


Fig. 8: Relationship Between Percent Rolling-Sieve Cohesion and Cohesion Rating for:

(a) Site, (b) Stockpile, (c) Laboratory

Note: Rating Scale: 1 - 3 Poor
4 - 7 Medium
8 - 10 Good

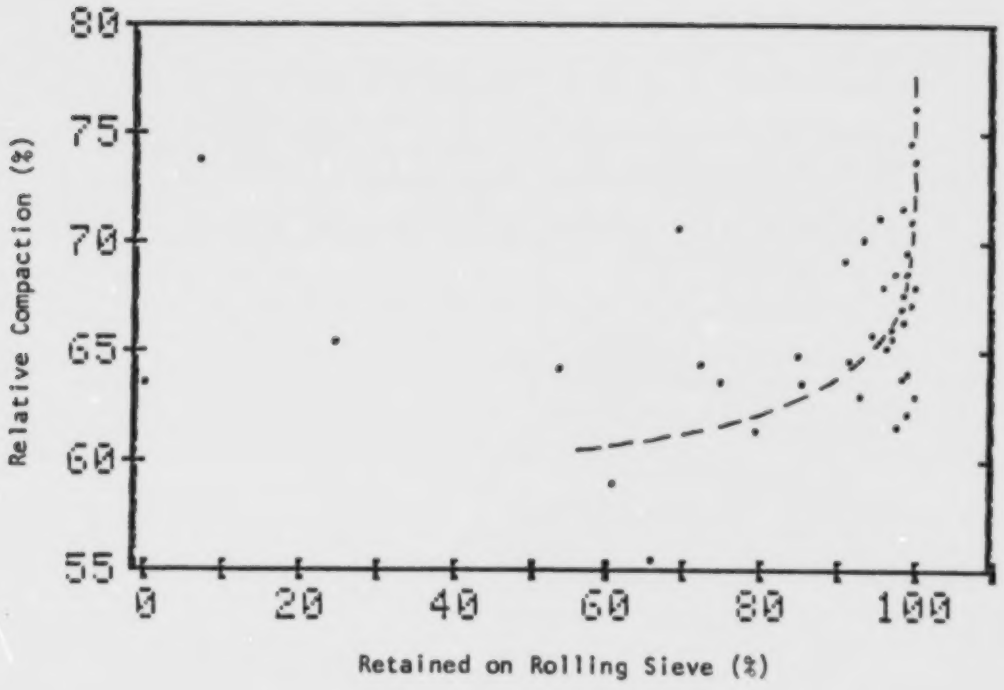
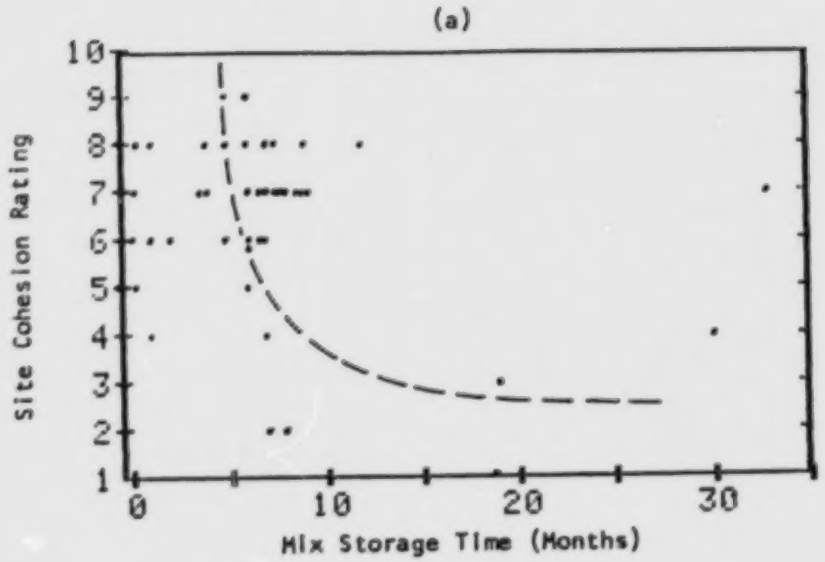
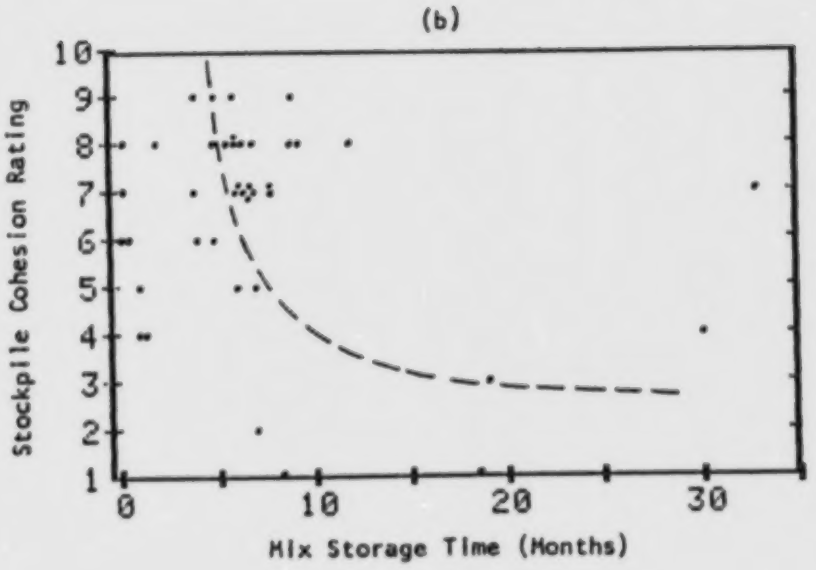


Fig. 9: Effect of Compactability (Relative Compaction, %) on the Retained Rolling Sieve (%)





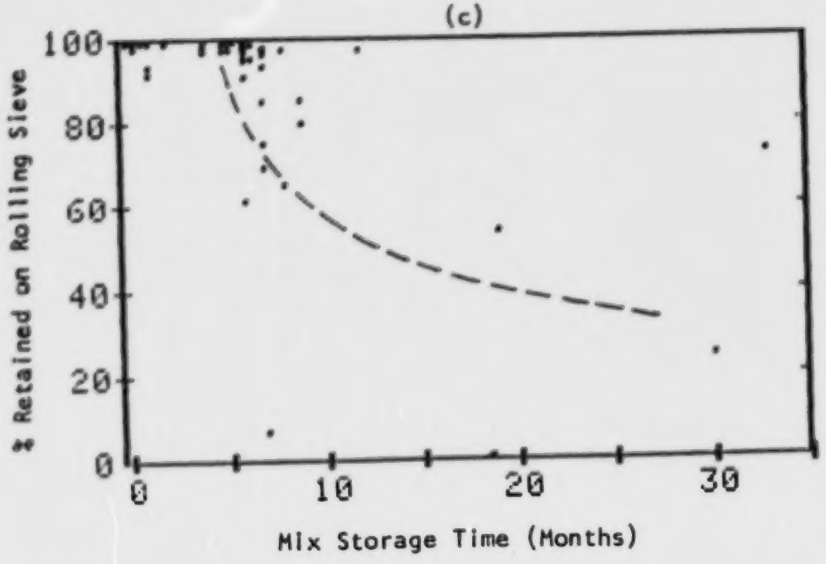


Fig. 10: Effect of Storage Time on Cohesion of Mixes:

a) Site Rating
b) Stockpile Rating
c) % Ret. on Rolling Sieve

Note: Rating Scale: 1 - 3 Poor
4 - 7 Medium
8 - 10 Good

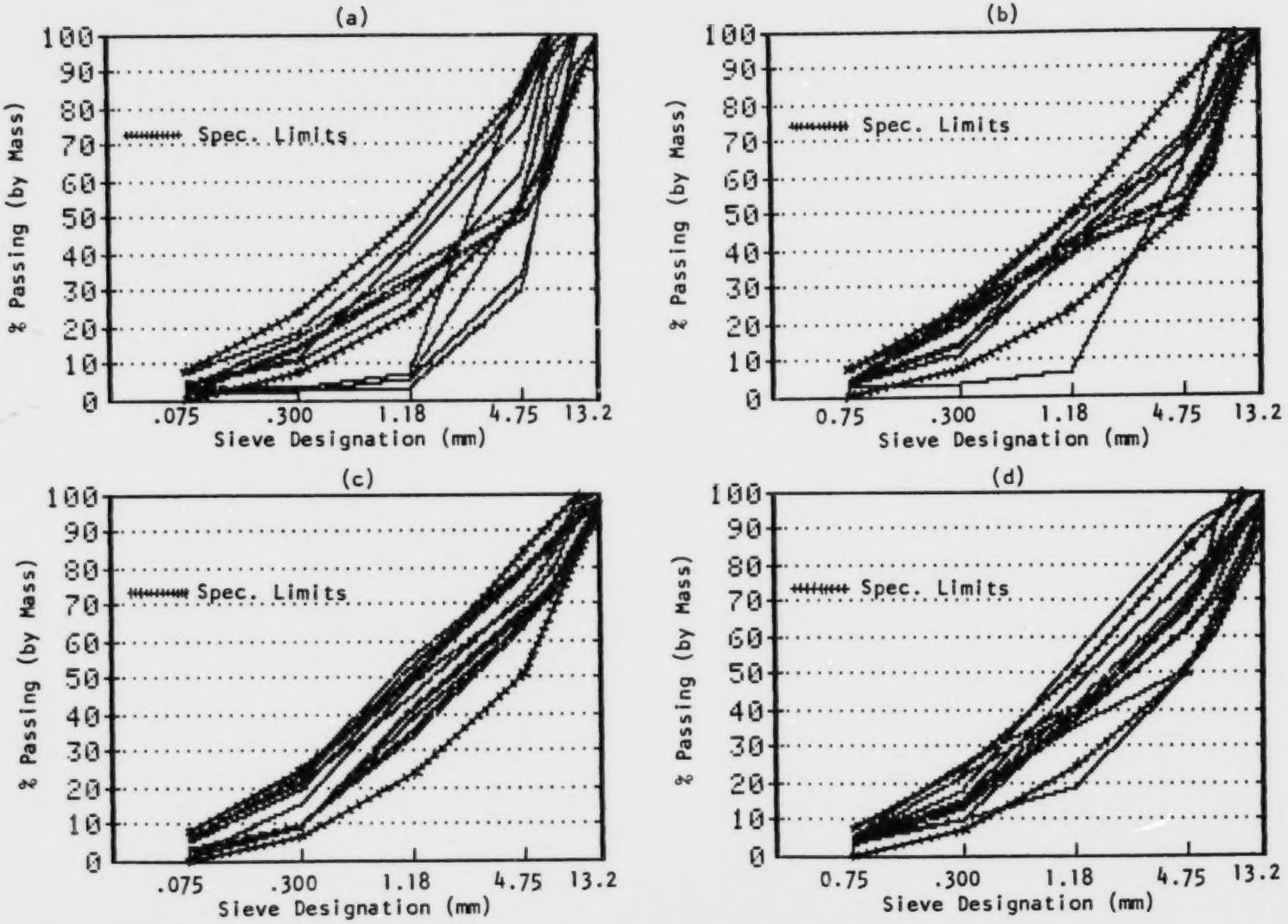


Fig. 11: Aggregate Gradations of Cold Patching Materials
(a) Mixes #1 to 10, (b) Mixes #11 to 20, (c) Mixes #21 to 30, (d) Mixes #31 to 40

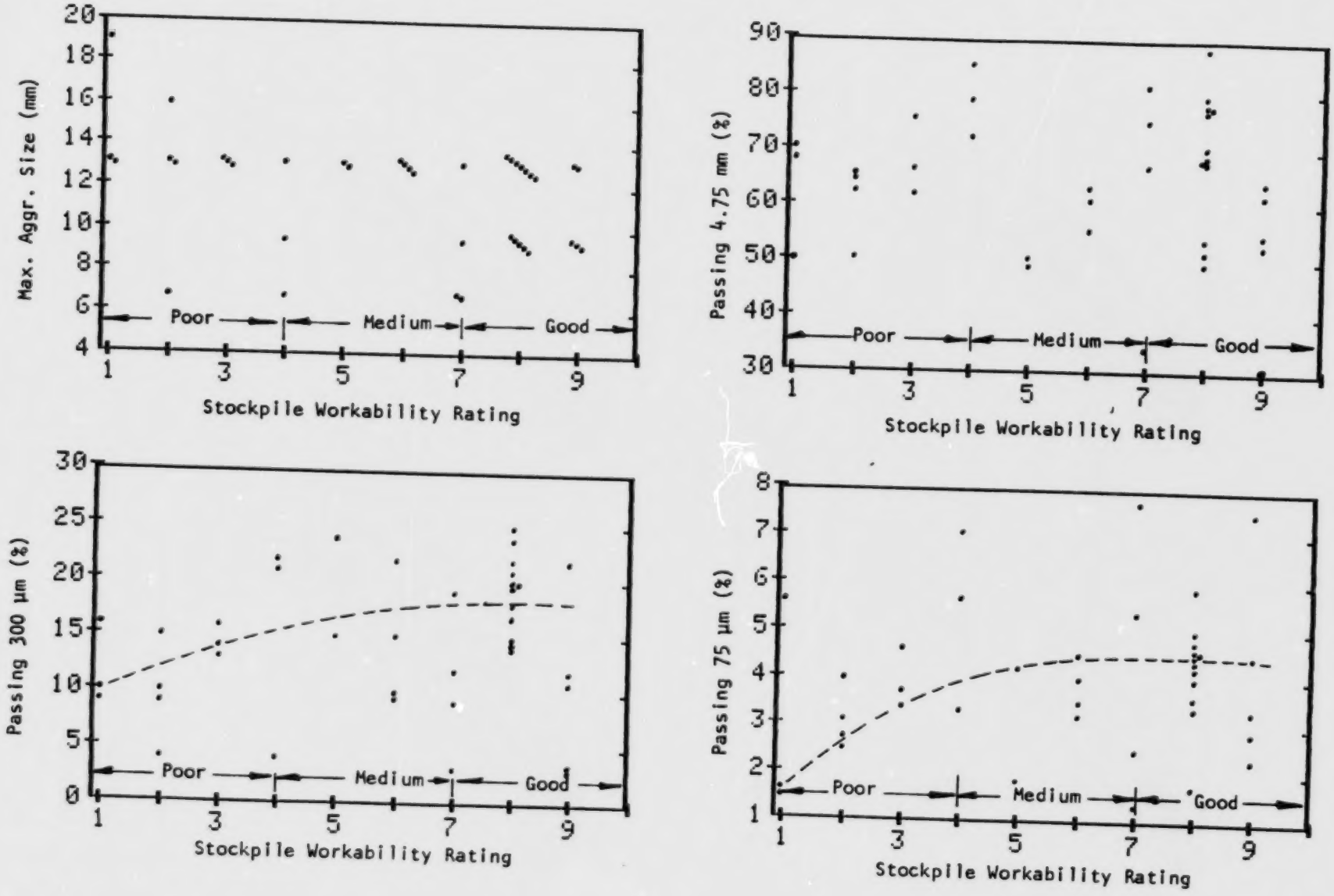


Fig. 12: Workability Rating (Stockpile) vs. Aggregate Gradation Parameters

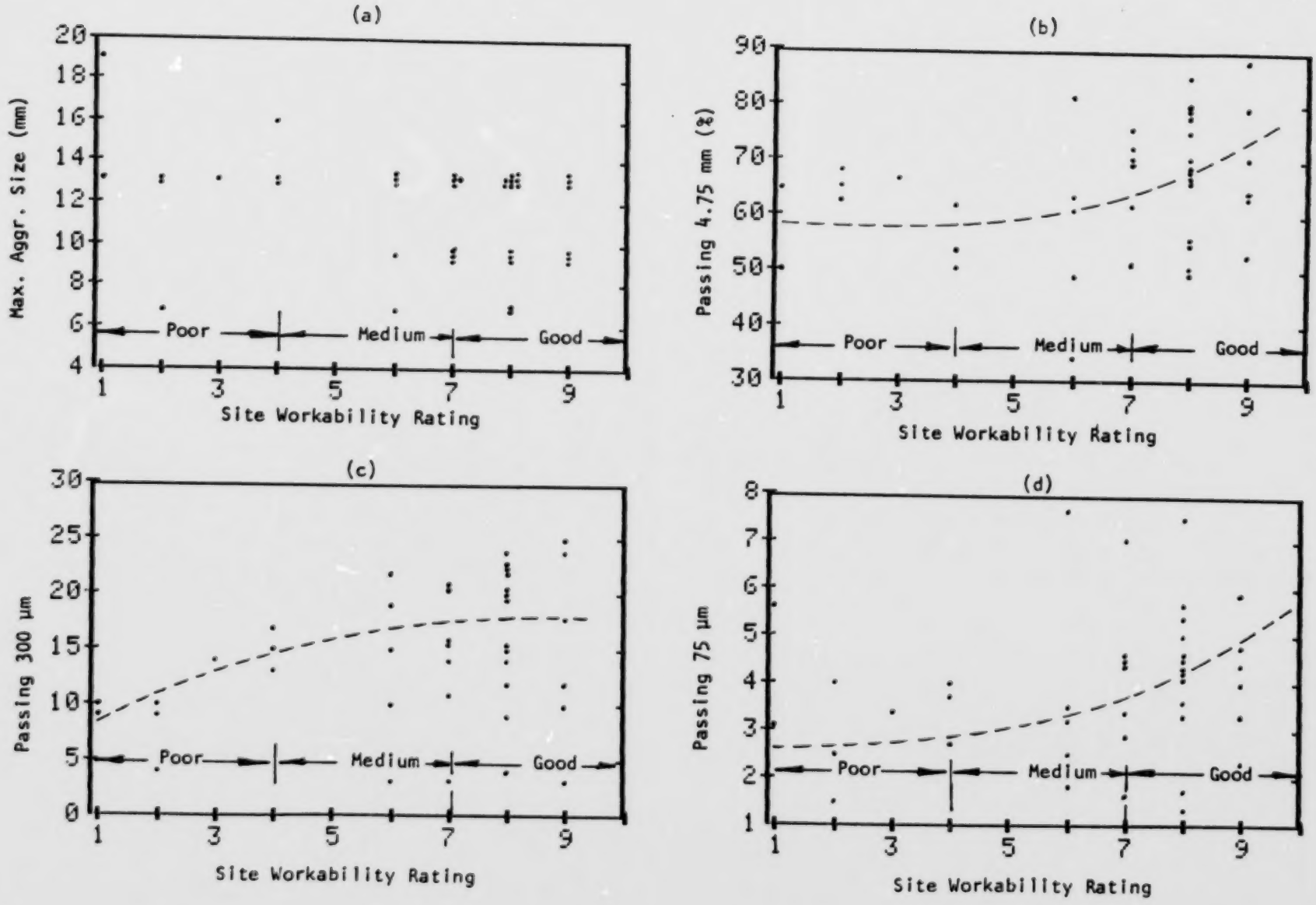


Fig. 13: Site Workability Rating and Aggregate Gradation Parameters

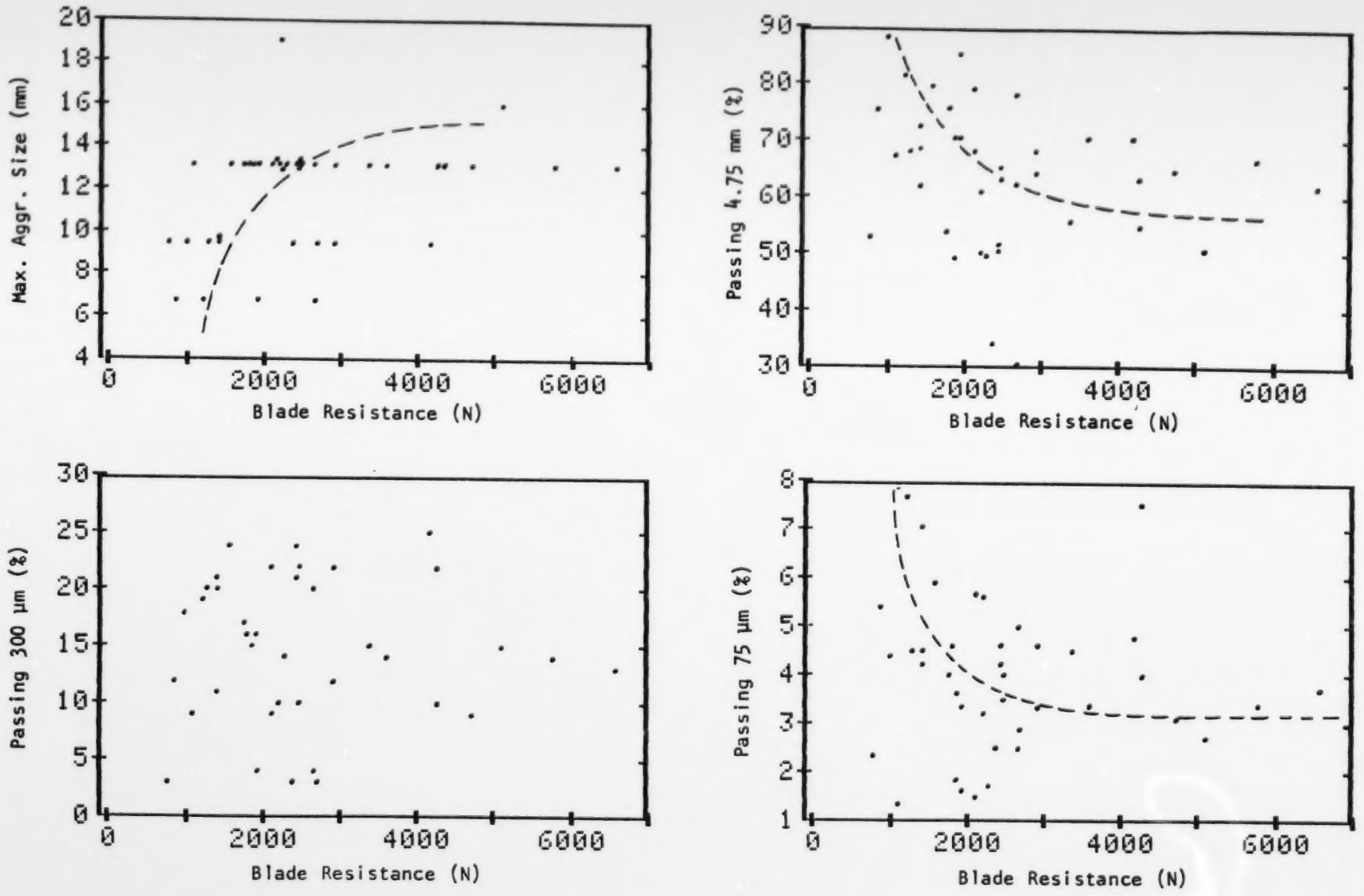


Fig. 14: Blade Resistance and Aggregate Gradation Parameters

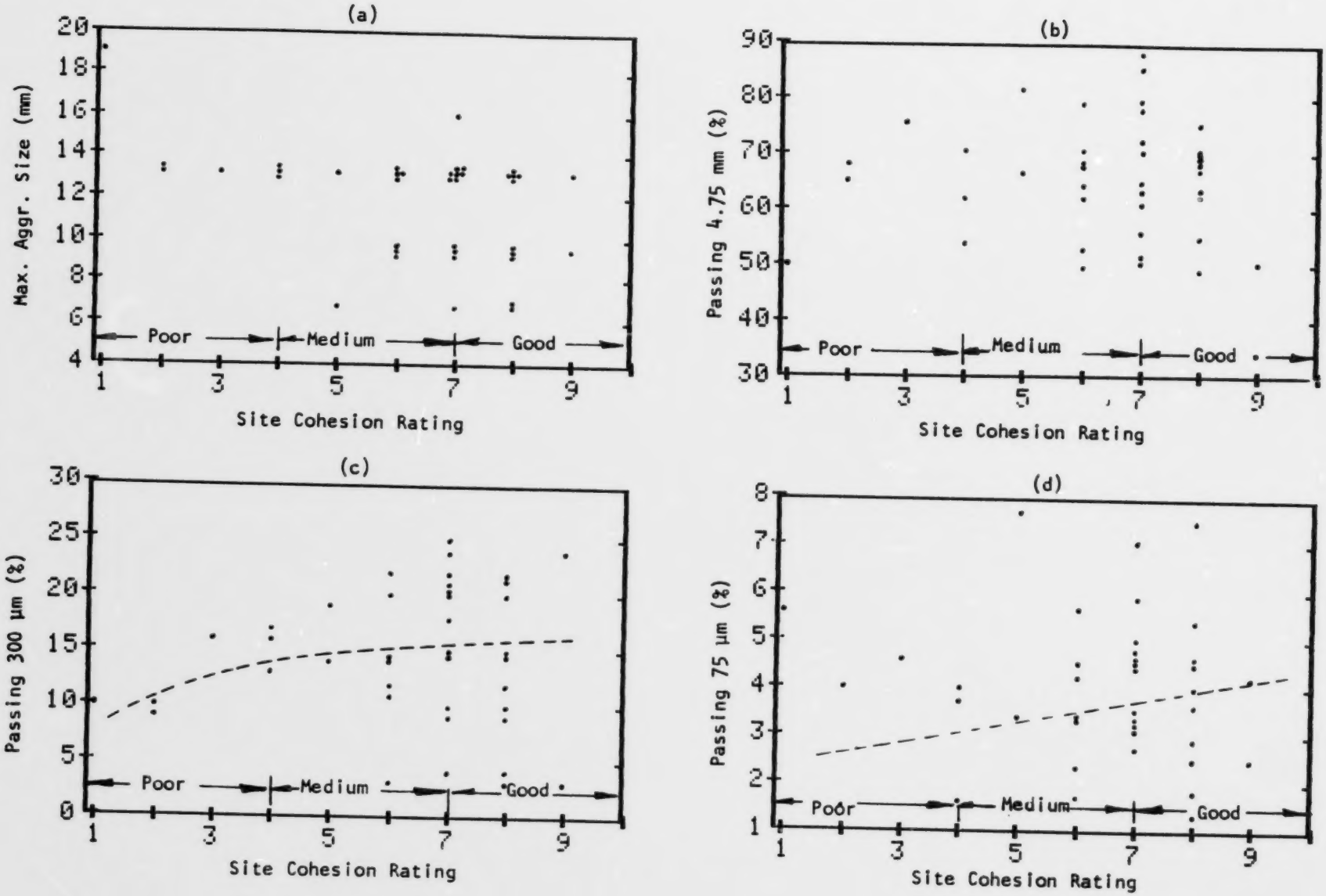


Fig. 15: Site Cohesion Rating and Aggregate Gradation Parameters

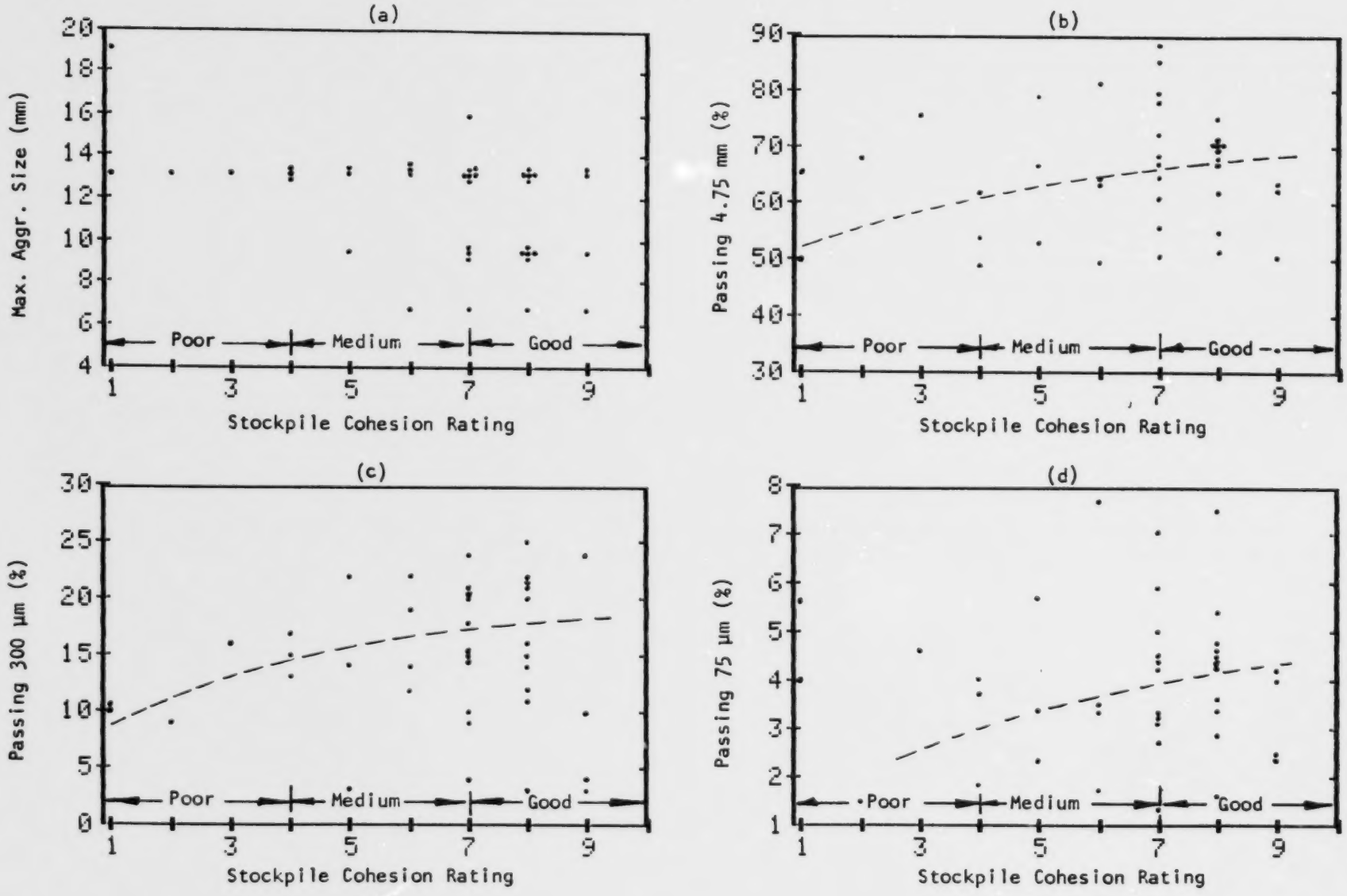


Fig. 16: Stockpile Cohesion Rating and Aggregate Gradation Parameters

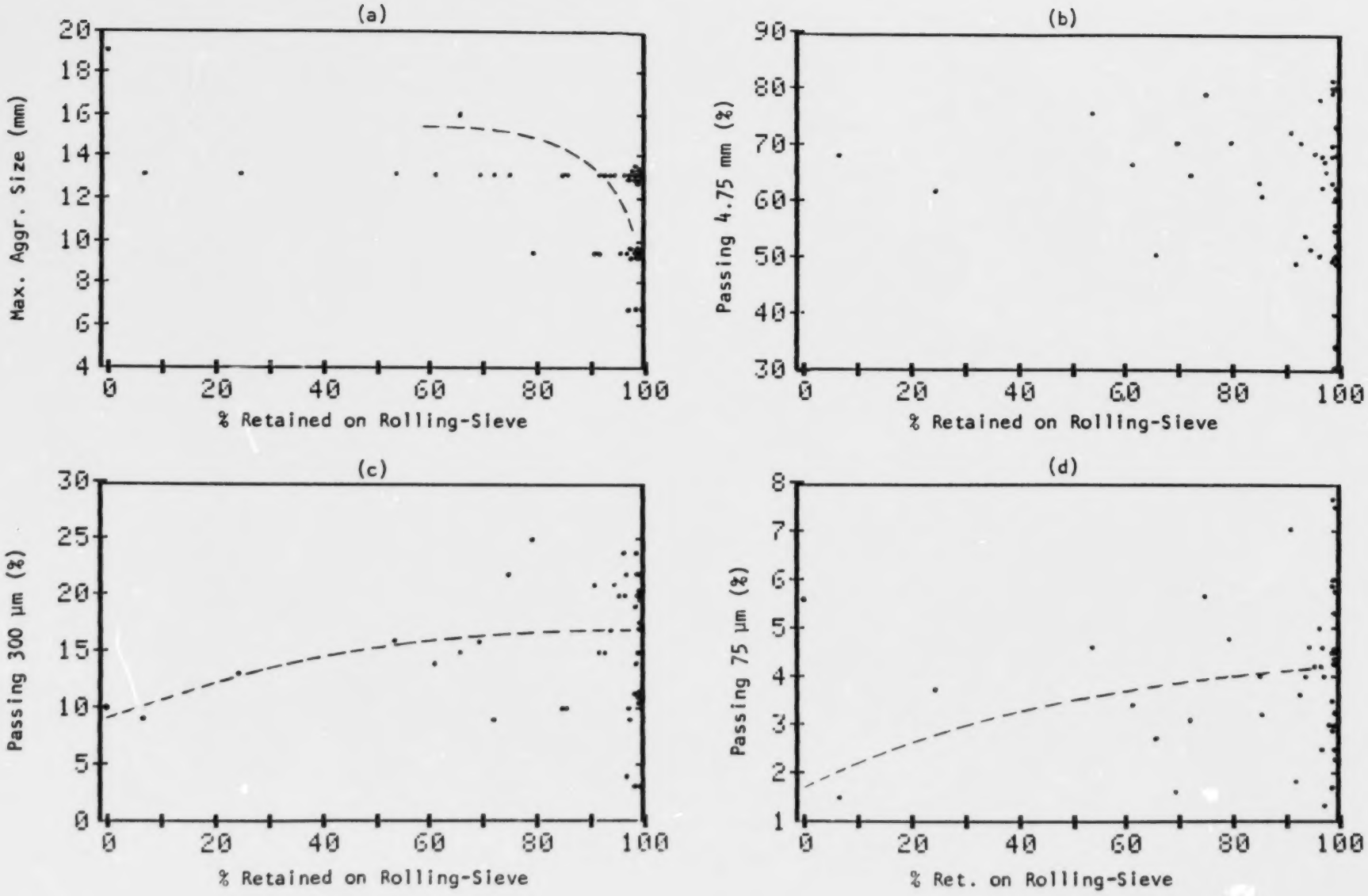


Fig. 17: Rolling-Sieve Cohesion Test Results vs. Aggregate Gradation Parameters

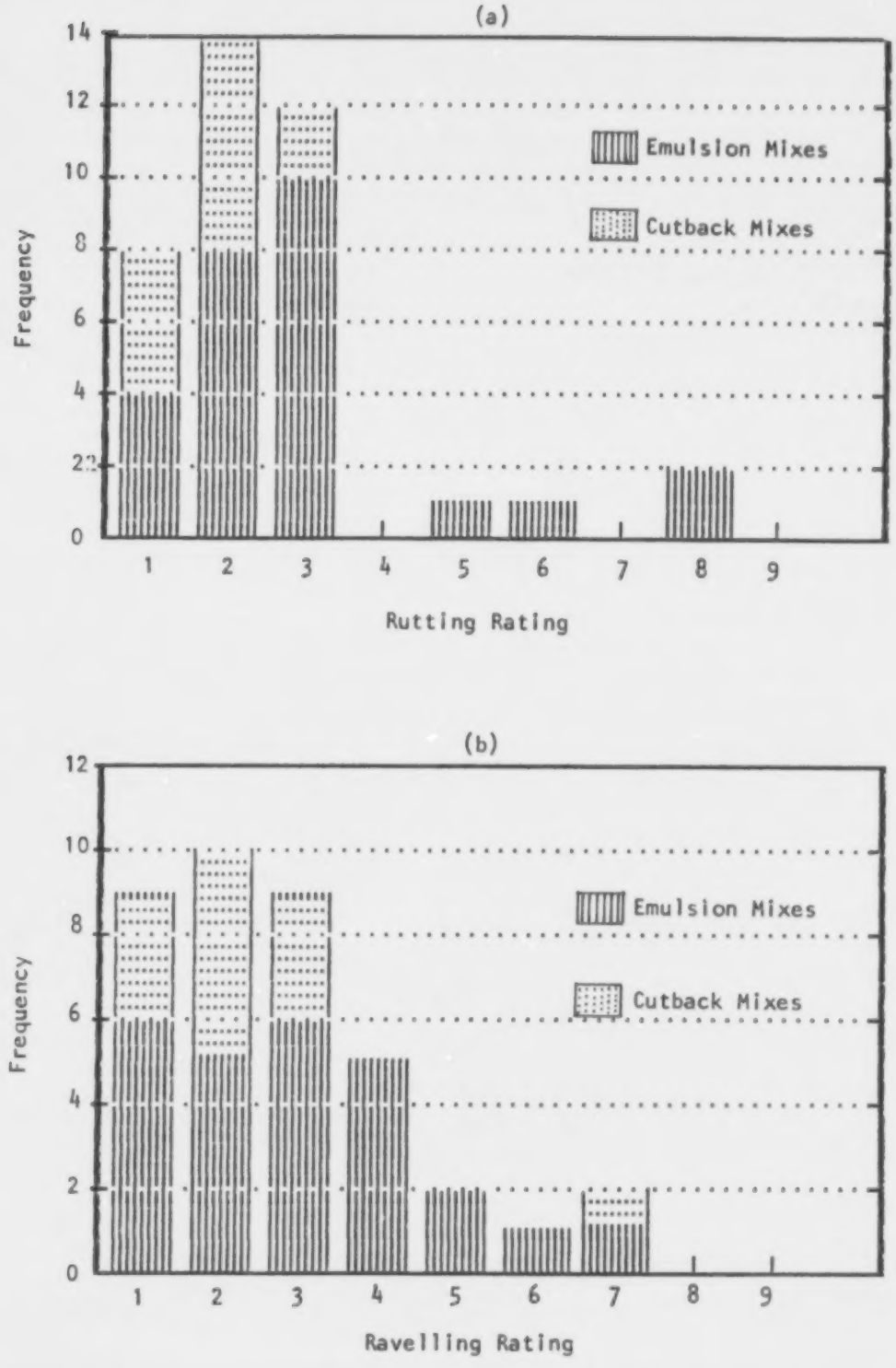


Fig. 18: Histogram of Field Condition Ratings of Cold Patching Materials

(Rating of 1-3 = slight,
4-7 = medium, 8-10 = severe)

APPENDIX 1

Material specification
for
SC -800 Hot Mix, Cold Laid Patching Material
and
Emulsified Asphalt Patching Material

ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION

(METRIC)
1152-1
OPSS 1152
DECEMBER 1983

MATERIAL SPECIFICATION FOR SC-800 HOT MIX, COLD LAID PATCHING MATERIAL

INDEX

1152.01	SCOPE
1152.02	REFERENCES
1152.03	DEFINITIONS - Not Used
1152.04	SUBMISSION AND DESIGN REQUIREMENTS - Not Used
1152.05	MATERIALS
1152.05.01	Liquid Asphalt
.02	Aggregates
1152.06	EQUIPMENT
1152.07	PRODUCTION
1152.07.01	Composition of Mixture
.02	Preparation of Liquid Asphalt
.03	Preparation of Mixture
.04	Delivery and Packaging
1152.08	QUALITY ASSURANCE
1152.09	AUTHORITY PURCHASE OF MATERIALS BY PURCHASE ORDER - Not Used
1152.10	DESIGNATED SOURCES REQUIREMENTS - Not Used

1152.01 SCOPE

This specification covers the requirements of the manufacture of SC-800 hot mix, cold laid patching material.

1152.02 REFERENCES

This specification refers to the following standards, specifications or publications:

Ontario Provincial Standard Specifications (Material)

OPSS 1001 - Aggregates - General
OPSS 1003 - Aggregates - Hot Mix Asphaltic Concrete
OPSS 1102 - Material Specificaton for Liquid Asphalts
OPSS 1150 - Material Specification for Hot Mix, Hot Laid Asphaltic Concrete

1152.05 MATERIALS

1152.05.01 Liquid Asphalt

The asphalt used shall be that designated as SC-800 and shall conform to OPSS 1102.

1152.05.02 Aggregates

The requirements of OPSS 1001 and OPSS 1003 as detailed for HL4 shall apply to this work.

1152.06 EQUIPMENT

Equipment shall conform to the requirements of OPSS 1150.

1152.07 PRODUCTION

1152.07.01 Composition of Mixture

The patching mixture shall contain between 4.0 and 6.0 percent of SC-800 by mass. The mixture shall conform to the gradation limits specified for HL4 in OPSS 1150.

The Engineer will designate the composition of the mixture. One or more mix proportions may be designated to suit job conditions.

1152.07.02 Preparation of Liquid Asphalt

The SC-800 liquid asphalt shall be heated at the asphalt plant to a temperature of 105°C ± 10°C.

1152.07.03 Preparation of Mixture

The mixture shall be prepared according to the requirements of OPSS 1150 except that the discharge temperature of the mixture shall be 105°C ± 10°C.

1152.07.04 Delivery and Packaging

The mixture shall be transported from the asphalt plant to the work in vehicles with smooth metal boxes in good and leak-proof condition, previously cleaned of all foreign materials.

Truck boxes shall be lightly coated with a uniform application of a release agent just before loading. If liquid agent is used, the truck boxes must be drained after each application and before loading.

1152.08 QUALITY ASSURANCE

The test results, based on current Authority testing procedures shall indicate that the composition of the mixture meets the following tolerances:

SC-800	plus or minus 0.3%
Coarse Aggregate (retained on 4.75 mm sieve)	plus or minus 5.0%
Passing 75 µm	plus or minus 1.0%

ONTARIO
PROVINCIAL
STANDARD
SPECIFICATION

(METRIC)
1153-1
OPSS 1153
DECEMBER 1983

MATERIAL SPECIFICATION FOR EMULSIFIED ASPHALT PATCHING MATERIAL

INDEX

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1153.01 SCOPE

This specification covers the requirements for the manufacture of emulsified asphalt patching material.

1153.02 REFERENCES

This specification refers to the following standards, specification or publications:

Ontario Provincial Standard Specifications (Material):

OPSS 1003 - Aggregates - Hot Mix Asphaltic Concrete

1153.05 MATERIALS

1153.05.01 General Requirement

The mix shall be so designed by the Contractor as to maintain its effective properties in stockpile for a minimum period of eight months from the date of supply to the Authority.

1153.05.02 Asphalt Emulsion

The asphalt emulsion shall have been specifically designed and formulated for the aggregates to be used.

1153.05.03 Mineral Aggregates

Mineral aggregates shall consist of a blend of coarse and fine aggregate such that not less than 85 percent of the portion passing a 4.75 mm sieve shall be natural sand.

The mineral aggregates shall consist of clean, hard, durable particles conforming to the physical requirements for HL 4 as specified in OPSS 1003.

1153.07 PRODUCTION

1153.07.01 Composition of the Mixture

The mineral aggregates and asphalt emulsion shall be combined and mixed in an asphalt plant to provide a uniformly coated and homogeneous product complying with the requirements of Table 1.

TABLE I

COMPOSITION OF THE MIXTURE

MTC SIEVE DESIGNATION	PERCENTAGE PASSING (By Mass)
13.2 mm	100
9.5 mm	85 - 100
4.75 mm	50 - 85
2.36 mm	35 - 65
1.18 mm	25 - 50
600 mm	15 - 40
300 mm	7 - 25
150 mm	2 - 13
75 mm	0 - 7

Residual Asphalt 3.7 - 5.5 percent

The percent residual asphalt shall be expressed as a percentage of the total mix.

1153.07.02 Preparation of the Mixture

The following controls have generally been found to produce suitable mixes:

Emulsion temperature	20 - 60° C
Mix temperature as discharged from drum mix plant	80 - 90° C
Mix temperature as discharged from batch or continous mix plant	95 - 110° C
Mixing cycle	40 - 60 s

1153.07.03 Transportation of the Mixture

Truck boxes shall be lightly coated with a uniform application of a release agent just before loading. If liquid agent is used, the truck boxes must be drained after each application and before loading.

The mixture shall be transported from the asphalt plant to the work in vehicles with smooth metal boxes in good and leakproof condition, previously cleaned of all foreign materials.

1153.08 QUALITY ASSURANCE

1153.08.01 Testing Procedures and Required Results

The mix shall possess adequate stripping resistance, workability and cohesiveness as determined by the following tests:

1153.08.01.01 Stripping Resistance

50 g of the cool mix will be placed in 400 mL of boiling distilled water in a 600 mL glass beaker. It will be stirred with a glass rod at one revolution per second for 3 min.

The percentage coating retained will then be visually evaluated. Retained coatings of less than 75 percent will constitute failure.

1153.08.01.02 Workability

The cool, loose mix will be placed in a minimum 300 mm x 450 mm x 65 mm flat metal pan to form an uncompacted layer 50 mm in depth and placed in a cold room or freezer, maintained at -10° C, for a period of 24 h. With the mix still in the cold room or freezer, the workability will be evaluated by penetrating and reworking the mix with a flat aluminum scoop.

In a workable mix the scoop will enter the sample with reasonable ease and the material may be mixed with very little conglomeration.

1153.08.01.03 Cohesion

The mixture shall perform satisfactorily when tested in accordance with the current Authority test methods for cohesiveness.

1153.09 AUTHORITY PURCHASE OF MATERIALS BY PURCHASE ORDER

1153.09.01 Measurement for Payment

Measurement of emulsified asphalt patching material will be in tonnes.

1153.09.02 Basis of Payment

Payment at the contract price for emulsified asphalt patching material shall be full compensation for all labour, equipment and materials required to supply and deliver the mixture.

APPENDIX 2

Method for Testing Workability for Cold Patching Material

TEST METHOD FOR WORKABILITY OF COLD BITUMINOUS PATCHING MATERIAL BY BLADE RESISTANCE

1. SCOPE

1.1 This method provides a measure of the workability of cold patching material in cold temperature.

2. APPLICABLE DOCUMENTS

2.1 MTO Form 1153-1 Material Specification for Emulsified Asphalt Patching Material.

2.2 MTO Method LS-261 Preparation of Marshall Specimens.

2.3 MTO Method LS-263 Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.

3. SUMMARY OF METHOD

3.1 The resistance of a compacted cold patching material to the penetration of a standard blade into the mix is measured using a modified Marshall apparatus.

3.2 The resistance in Newton (N) to the penetration of the blade after 30 seconds is used as the measure of mix workability at -10°C conditions. The higher the resistance, the poorer is the workability.

4. SIGNIFICANCE AND USE

4.1 The method simulates the penetration action of a shovel or scoop while it is removing a mix from a stockpile or truckbox. The resistance of a mix to handling in cold temperature is a measure of the workability.

4.2 The method quantifies mix workability rather than giving subjective evaluation such as using a flat scoop, as is specified in current MTO Form 1153.

5. APPARATUS

5.1 Two wooden boxes measuring 265 mm x 165 mm x 50 mm deep, inside dimensions, and sufficiently rigid for forming and testing of cold mix specimen.

5.2 Compaction hammer, hand type (according to LS-261) with a modified flat tamping foot of 150 mm x 150 mm x 6 mm thick attached to the bottom of hammer.

5.3 Freezer/cold room: capable of maintaining temperature at -10 ± 2°C

5.4 Marshall Testing Machine (according to LS-263), modified by attaching a steel blade of dimensions 130 mm x 50 mm x 3 mm thick to the adapter at the bottom of proving ring.

5.5 Support stand (any stand of suitable height and configuration for supporting the wooden box).

5.6 Metal scoop.

5.7 Thermometer: a type suitable for measureing the temperature of a mix in the range of +25 to -25°C, with an accuracy of ± 2°C.

5.8 Metal pans or bowls.

5.9 Balance, 5 kg capacity, with an accuracy of 1 g.

5.10 Stop watch.

5.11 Rubber gloves.

5.12 Marking crayons.

6. PREPARATION OF TEST SPECIMENS

6.1 Prepare two specimens using the material to be tested.

6.2 Preparation of Mix:

6.2.1 Bring sample of the bituminous mixture (about 5 kg) to room temperature (21 ± 3°C).

6.2.2 Weigh into two separate wooden boxes the amount of cold patching (about 2 kg) that will result in a compacted specimen of 48 to 50 mm in height.

6.2.3 Spread the mix uniformly over the box and level the mix surface, avoiding any segregation. Discard any excess material.

6.3 Compaction of Specimens:

6.3.1 Place the box with the material on any hard, levelled surface (for example, floor or compaction pedestal).

6.3.2 Place the compaction hammer with the modified foot close to one side of the box and apply two blows with the hammer (Fig. 1). Then apply another two blows to the other side of the box.

6.4 Mark three locations along the length of the box, approximately at 1/4 points, to indicate the position for the blade penetration (Fig. 1).

6.5 Place the compacted material and the box in a freezer or cold room for a minimum of 12 hours (e.g. overnight) at -10°C.

7. PROCEDURE

7.1 Attach the penetration blade to the adapter at the bottom of proving ring of the Marshall apparatus with the blade parallel to the front of the machine (Fig. 2).

7.2 Check the Marshall apparatus and adjust the dial indicator to zero.

7.3 Transfer the box with the compacted material from the freezer or cold room to the Marshall apparatus. Place it under the blade on the support stand, ensuring that it is level and firmly seated on the support stand (Fig.2).

7.4 Switch on the motor and bring the specimen close to the penetration blade. Position the specimen at the marked location.

7.5 Continue the upward movement of the jack head and start the stop watch when the dial indicator begins to move. Watch the dial carefully and record its reading when the penetration time approaches 30 seconds.

7.6 Lower the machine jack head and move the specimen to the next testing position. Clean the blade if necessary. Repeat the blade penetration procedure for the remaining two locations. Record the readings on the dial indicator.

7.7 Repeat the above testing procedure on the second specimen prepared using the same cold mix material.

8. CALCULATIONS AND REPORT

8.1 Multiply each of the three dial readings by a calibration factor as determined for the ring dynamometer to calculate the blade resistance values.

8.2 Determine the average of the three values as the resistance of the material to the blade penetration.

8.3 Repeat the same for the second specimen and report the average of the two sets of results as blade resistance at -10°C.

8.4 The report shall include the following:

8.4.1 Identification and description of the mix sample.

8.4.2 Calculated results for each sample and average result of the duplicate tests.

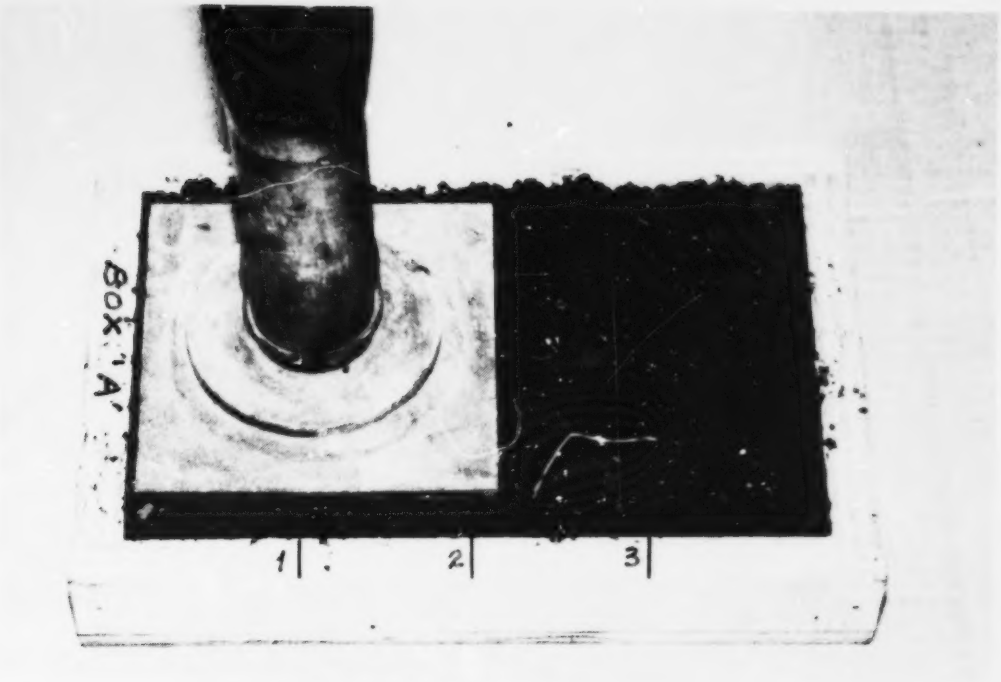


Fig. 1: Compaction of Specimen

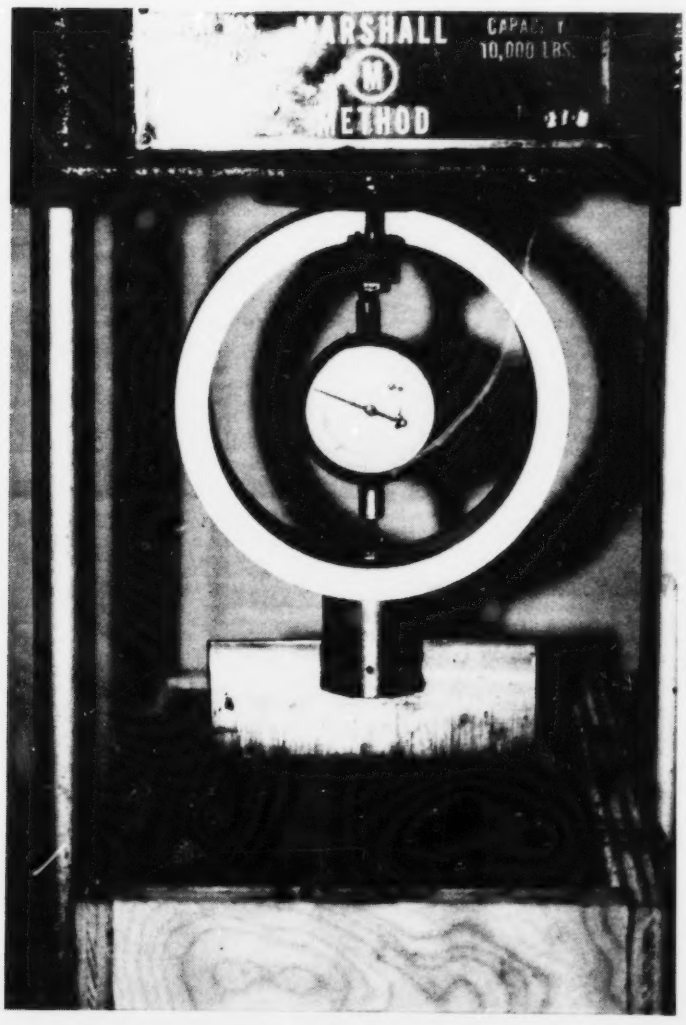


Fig. 2:

Blade Penetration Testing

APPENDIX 3

Method for Testing Cohesion of Cold Patching Material

TEST METHOD FOR COHESION OF COLD BITUMINOUS PATCHING MATERIAL BY ROLLING-SIEVE

1. SCOPE

1.1 This method provides a measure of the cohesiveness of cold patching materials in cold temperature.

2. APPLICABLE DOCUMENTS

2.1 MTC method LS-261 Preparation of Marshall Specimens

3. SUMMARY OF METHOD

3.1 The cohesion between mix particles is assessed by rolling a compacted briquette in a 305 mm diameter opening sieve sideways back and forth twenty times.

3.2 The mass of material retained on the sieve to the total mass of the briquette produces an index in percent retained mass. A high percent retained mass indicates good cohesion of a mix.

4. SIGNIFICANCE AND USE

4.1 The method can be used for quantifying the cold patching material cohesiveness to determine its resistance to ravelling due to the action of traffic.

4.2 A minimum percent retained on the sieve may be specified to prevent the use of low cohesive patching materials.

5. APPARATUS

5.1 A set of Marshall compaction apparatus:

- one set of Marshall mold assembly
- compaction hammer, hand type
- pedestal, for hand compaction
- metal scoop, flat bottomed

5.2 Freezer/cold room: capable of maintaining temperature at -10 ± 2°C.

5.3 Balance: 200 g capacity, sensitivity to 1 g.

5.4 Thermometer: a type suitable for measurieng the temperature in the range of +25 to -25°C, sensitivity to ± 2°C.

5.5 Metal pans (Fig. 1):

5.5.1 One 400 mm square x 100 mm deep pan.

5.5.2 Four with 1000 g holding capacity.

5.6 Metal tray with an inside dimension of 550 mm length, 445 mm width, 105 mm height (Fig. 1).

5.7 Specimen extractor: hand type, suitable for extracting the compacted specimen from the mold with the use of mold collar.

5.8 Standard sieve: 19 mm (0.75") square openings, 305 mm (12") in diameter, 82.6 mm (3.25") in height, with the sieve cover fitted sufficiently tight to keep the specimen inside during the test (Fig.1).

5.9 Rubber gloves.

5.10 Stop watch or timer.

6. PREPARATION OF SPECIMENS

6.1 Prepare three specimens using the material to be tested.

6.2 Weigh into separate pans the amount of cold patching mix (about 1100 g) that will result in a compacted specimen of 63.5 ± 2 mm (2.5") in height.

6.3 Place the pans and mix in a freezer and store for at least l2 hours at -10°C.

6.4 Place the specimen mold assembly and hammer head in the freezer for at least 2 hours.

6.5 Remove the patching mix and equipment from the freezer and

immediately place a piece of filter paper at the bottom of the mold before the mixture is introduced. Level roughly its surface by hand before placing another piece of filter paper on top.

6.6 Place the mold assembly on the compaction pedestal in the mold holder and apply five (5) blows with the compaction hammer with a free fall of 457 mm (18"). Reverse the mold and mix assembly and apply anther five blows of compaction to the specimen.

7. PROCEDURE

7.1 After compaction, carefully extrue the specimen into the extension collar and transfer the speciment to a diametrally positioned test sieve in a metal tray on a levelled surface (Fig. 2).

7.2 Place the compacted briquette diametrally on the lowest point of the sieve with the flat face facing the wire mesh.

7.3 Place the sieve cover tightly on the sieve and bring the sieve to one side of the metal tray. Roll the compacted briquette in the 305 mm diameter opening sieve sideways back and forth twenty (20) times. The rolling should last about 20 seconds.

7.4 Pick the sieve up from the pan and hold it to a horizontal position. Strike the side of the sieve slightly with a hand and allow all particles separated from the specimen to pass through the sieve openings (Fig. 3).

7.5 Place both the retained and passed portions of the material in separate containers and determine the mass of both portions by weighing on a balance to the nearest gram (Fig. 4).

8. CALCULATION AND REPORT

8.1 Calculate the percent retained on the sieve as follows:

$$RS = \{r/(r+p)\} \times 100\ \%$$

where: RS = percent of cold patching mix retained on 19.1 mm sieve
r = mass of mix retained on 19.1 mm sieve after rolling
p = mass of mix passed through the 19.1 mm sieve after rolling

8.2 The report shall include the following:

8.2.1 Identification and description of the sample.

8.2.2 Calculated results for each sample and average result of triplicate tests.

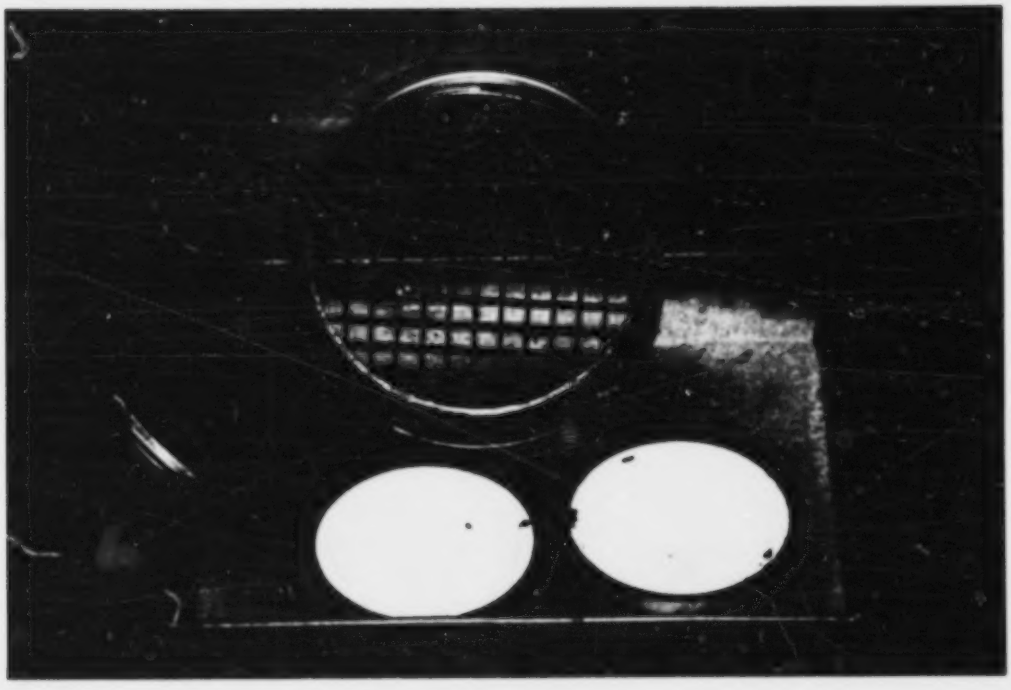


Fig. 1: 305 mm Diameter Sieve, Metal Tray and Pans

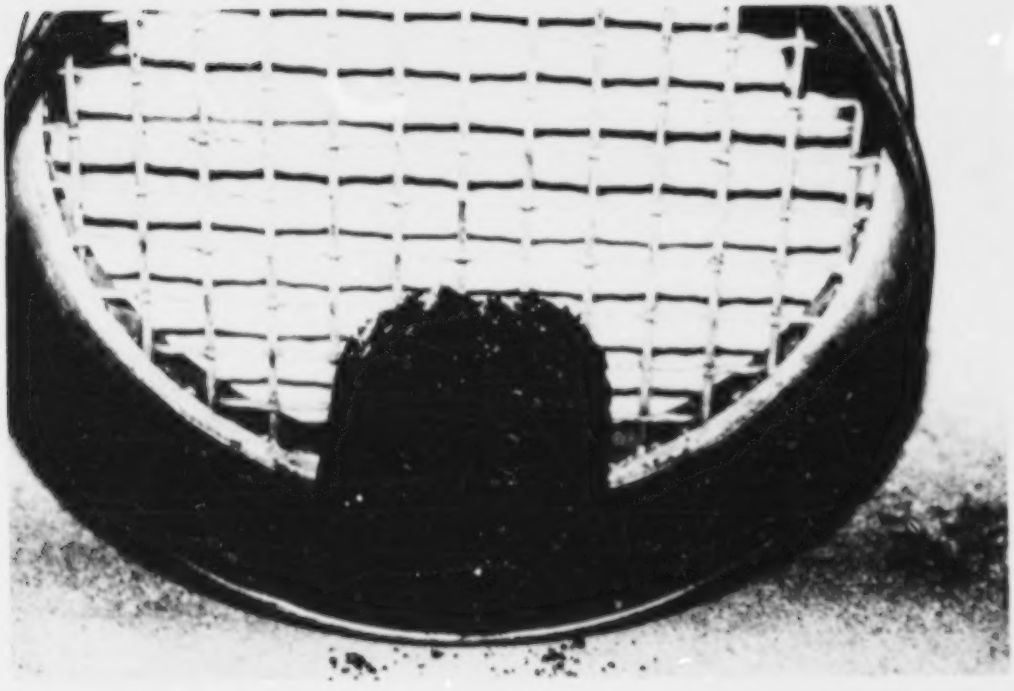


Fig. 2: Diametrally Positioned Sieve and Specimen

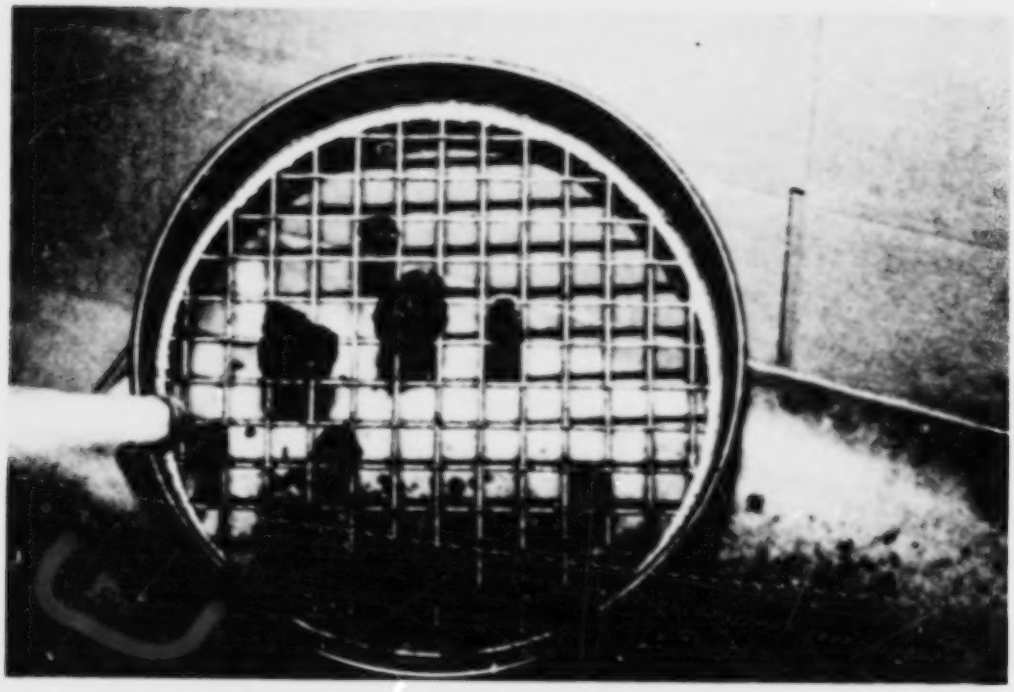


Fig. 3: Materials Retained on Sieve After Rolling

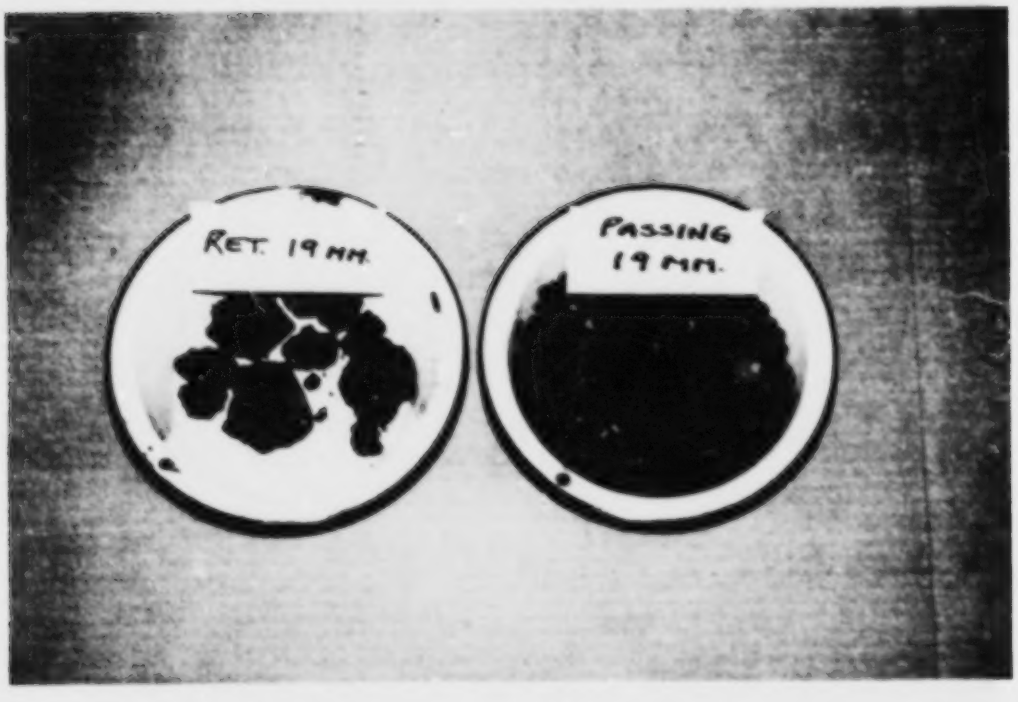


Fig. 4: Mass of Materials Retained and Passing the Sieve After Rolling

APPENDIX 4

Memorandum on the Initial Development of Test Methods for Cold Patching Material

Ministry of Transportation and Communications
Ontario

Memorandum

To: Mr. D.F. Lynch,
Head,
Bituminous Section.

From: K.K. Tam

Attention:

Date: 84 02 22

Our File Ref.

In Reply to

Subject: MTC Form 1153 - Material Specification for Emulsified Asphalt Patching Material

The above specification is currently under revision, which will make reference to quality assurance and test requirements. They are based on the following tests:

(a) Determination of stripping resistance.
(b) Determination of workability at -10°C.
(c) Determination of cohesiveness of the mixture.
(d) Quantitative extraction of bitumen from bituminous paving mixture as per LS-282.

On reviewing existing test procedures, I have found that tests for (a) and (d) are in good order whereas tests (b) and (c) are very subjective in nature. This makes it difficult to set criteria for acceptance/rejection purposes. In addition, current literature so far reveals that quantitative tests are unavailable for testing workability and cohesion. Hence, I have developed the following two tests, namely,

(i) Rolling-Sieve test for determination of cohesion index of cold patching mixture.
(ii) Resistance to Blade Penetration test for measuring the workability of cold patching mixture.

Laboratory evaluations on mixtures of different workability and cohesion show that results of the two proposed tests correlate well with visual ratings, (e.g. Figs. 1 & 2). The tests also appear to discriminate the mixes and can divide the mixtures into four types, as shown in Fig. 3.

In order to confirm these tests with the performance of mixtures in field environment, I suggest that the attached data collection questionnaire be sent to the Regions for completion, and together with the samples to be sent to Downsview for testing.

The information and test results will then be analyzed and form the basis for setting property requirements. The test methods can be used for quality control of patching materials.

For your consideration.

K. K. Tam,
Sr. Bituminous Engineer.

KKT:mv

FIG. 1

ROLLING-SIEVE TEST RESULTS

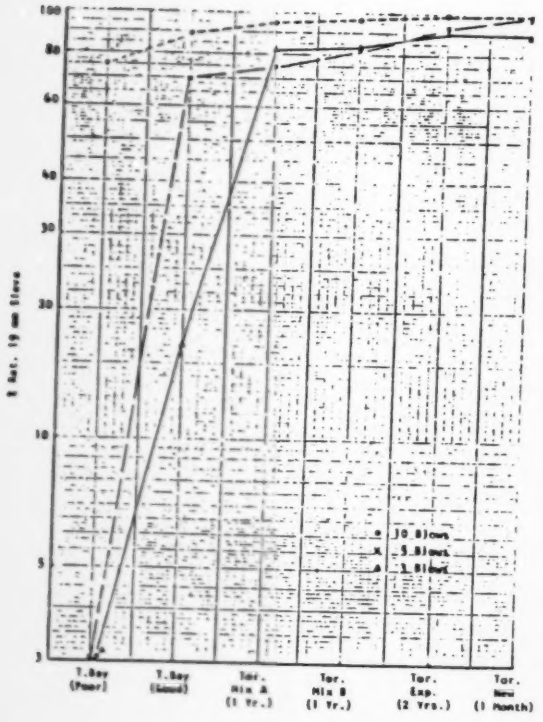


FIG. 3

MIX CHARACTERISTIC OF COLD PATCHING MATERIALS
(BY ROLLING-SIEVE TEST AND BLADE RESISTANCE TEST)

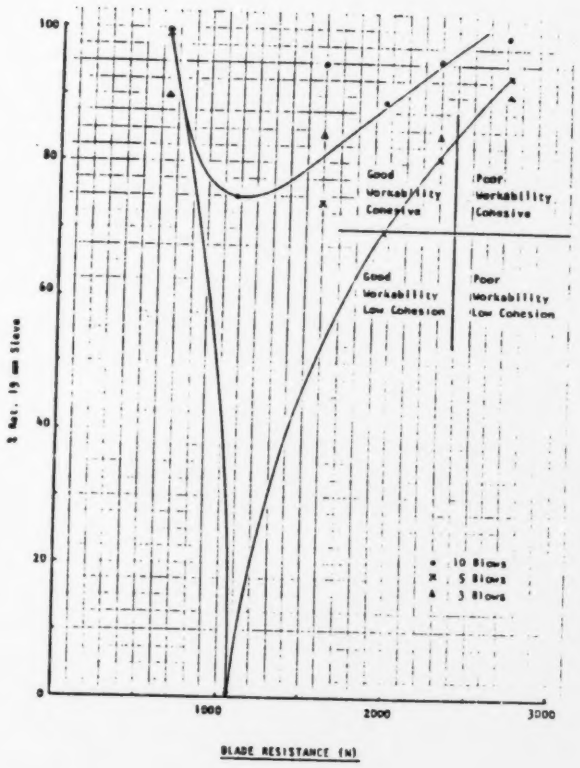
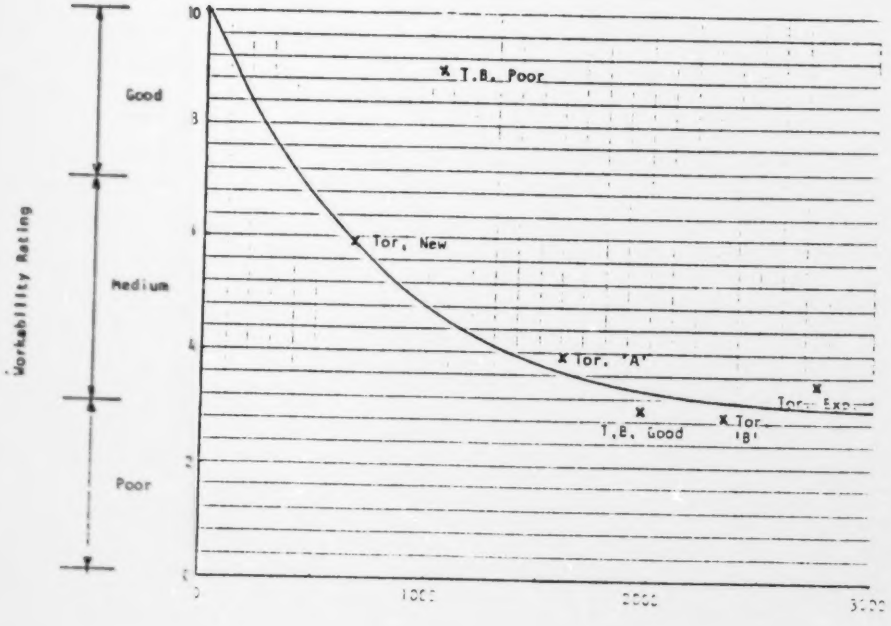


FIG. 2

RELATIONSHIP BETWEEN VISUAL WORKABILITY RATING
AND RESISTANCE TO BLADE PENETRATION



BLADE RESISTANCE (N)

APPENDIX 5

Questionnaire

COLD PATCHING MATERIAL DATA

PART I - FIELD DATA ON COLD PATCHING MATERIALS

Q 1 Site Location:

Q 2 Date of Patching:

Mix Information:

Q 3 Type (e.g. Hot-mixed, Cold-mixed or U.P.M., etc.) _____

Q 4 Binder: ☐ Cutback ☐ Emulsion

Grade (e.g. HF 1000 etc.) _____

Q 5 Aggregate(s) _____

STOCKPILE INFORMATION

Q 6 & 7 Age: _____ Approximate Height: _____

Q 8 Location: _____

MIX HANDLING PROPERTIES (Circle appropriate number)

(A) STOCKPILE

Q 9 Workability - relative ease of removing materials from stockpile

Poor			Medium				Good		
1	2	3	4	5	6	7	8	9	10

Q 10 Cohesion - Stickiness of materials i.e. adhesion between particles

1	2	3	4	5	6	7	8	9	10

(B) SITE

Q 11 Workability - relative ease of shovelling, raking, and shaping the materials

1	2	3	4	5	6	7	8	9	10

Q 12 Cohesion - Stickiness of materials i.e adhesion between particles

1	2	3	4	5	6	7	8	9	10

APPLICATION CONDITIONS:

Q 13 (A) Any heated storage of materials before patching: YES NO (circle appropriately)

(B) POTHOLES

Q 14 Average size (e.g. about 10 in. diameter) _____

Q 15 Average depth (e.g. 2 in.) _____

Q 16 Other areas (describe, e.g. longitudinal cracks, joint cracks, etc.):

_____

Q 17 Condition (tick appropriately)

☐ dry, ☐ wet, ☐ ponded water, ☐ ice/snow removed

(C) CLIMATE

Q 18 Air temperature _____

Q 19 Mix temperature _____
(if heated storage)

Q 20 (D) Compaction Method: (describe, e.g. by roller, hand tampering or drives over a few times, etc.):

_____

_____

_____

PART II - PERFORMANCE DATA ON COLD PATCHING MATERIALS

(A) WINTER (review at the same winter of patching after at least one week of opening to traffic)

		LIGHT			MEDIUM				SEVERE		
Q 21	Rutting/pushing	1	2	3	4	5	6	7	8	9	10
Q 22	Ravelling	1	2	3	4	5	6	7	8	9	10

Q 23 Air Temperature at time of review _____

Q 24 Date of review _____

(B) SUMMER (if past summer performance of the material is known)

Q 25 Site Location _____

Q 26 Approximate Date of Patching _____

Q 27 Rutting/pushing 1 2 3 4 5 6 7 8 9 10

Q 28 Ravelling 1 2 3 4 5 6 7 8 9 10

Q 29 Other observations _____

SAMPLE

(1) Taken at the time of patching from the materials used for the patching.

(2) Quantity required = 30 kg (60 lb) e.g. about 6x1 gal can.

(3) Place in air-tight containers e.g. the 1 gal triple sealed can.

(4) Mark on containers (a) site location (b) date of patching (c) district number (d) Cold Asphalt Mix.

(5) Send to Ministry of Transportation and Communications, Engineering Materials Office, Bituminous Evaluation Laboratory, Downsview, Ontario. M3M 1J8 (addressed labels provided) immediately after completion of patching.

QUESTIONNAIRE

(6) Send data to Ministry of Transportation and Communications, Bituminous Section, Rm. 317, Central Bldg., 1201 Wilson Avenue, Downsview, Ontario, M3M 1J8 to the attention of K. K. Tam.

Patrol Supervisor _____

District _____